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XXXII (1946)

PART I: BOTANY AND FORESTRY

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PAPERS OF THE MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS
EUGENE S. McCARTNEY
HENRY VAN DER SCHALIE

VOLUME XXXII (1946)
PART I: BOTANY AND FORESTRY

"Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat."
— SENECA, *Naturales Quaestiones*

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BOTANY

INTERESTING SPECIES OF VASCULAR PLANTS COLLECTED IN WESTERN MICHIGAN

CLAYTON W. BAZUIN

THE following list of vascular plants represents the species and varieties collected in Michigan in the eight years from 1938 to 1945, inclusive. So far as I have been able to learn, the species here listed have not previously been reported for the western part of the state. To determine the distribution the herbaria of the University of Michigan, Michigan State College, Aquinas College, University of Notre Dame, the Chicago Museum of Natural History, and the private collection of C. R. Hanes, Schoolcraft, Michigan, were studied or consulted. All available publications were searched so as to be sure that each species is either rare or new for western Michigan. The numbers after the locality citations are my collection numbers. Unless otherwise noted, the records are based upon my own collections.

My determinations of species have been checked by the following authorities: J. R. Swallen for Gramineae; F. G. Hermann for Carex and Juncaceae; Mrs. B. R. Clarke for aquatics, asters, and Solidago; H. K. Svenson for Eleocharis.

Specimens are preserved in my herbarium and in those of the following institutions: the University of Michigan, Ann Arbor, Michigan; Michigan State College, East Lansing, Michigan; Aquinas College, Grand Rapids, Michigan; the Cranbrook Institute of Science, Bloomfield Hills, Michigan; the Chicago Museum of Natural History, Chicago, Illinois; the Brooklyn Botanical Garden, Brooklyn, New York; Harvard University (Gray Herbarium); and the National Museum, Washington, D.C.

List of Species

Botrychium multifidium (Gmel.) Rupr. var. silaifolium (Presl) Broun. — A very rare fern. Its rarity may be due to its appear-

ance late in the summer. Low wet woods on north side of Camp Lake, Kent Co., no. 2198, Sept. 29, 1942; densely wooded ravine, Grand Rapids Township, Section 2, Kent Co., no. 6015, April 4, 1944; boggy meadow, Robinson Township, Section 35, Ottawa Co., no. 5137, Sept. 18, 1943.

Botrychium simplex Hitchcock. — A rare fern; found by Mr. Charles Nelson on the boggy border of Black Ash Swamp, south of Grand Rapids, Byron Township, Section 13, Kent Co., 1939.

Polypodium virginianum L. — Much more abundant than the records indicate, especially in the dunes of Lake Michigan. Wooded slopes, Bostwick Lake region, Kent Co., Charles Nelson, 1938; dunes near Stony Lake, Oceana Co., no. 4747, July 4, 1942; wooded slopes on shore of Pigeon Lake, Ottawa Co., no. 5824, Sept. 8, 1943; Macatawa Park, Ottawa Co., no. 1809, July 30, 1940; dune slopes, Leeland, Leelanau Co., Sister M. Marcelline Horton, Aquinas College, Grand Rapids.

Isoetes lacustris L. — Apparently very rare, since this is the only Isoetes I have ever collected. In shallow water on south side of Soft Water Lake, Grand Rapids, Kent Co., no. 619, Aug. 4, 1939.

Potamogeton crispus L. — A European species slowly spreading in the Great Lakes. Abundant in Reed's Lake, East Grand Rapids, Kent Co., no. 941, 1939; Pickerel Lake, Kent Co., no. 2435, July 7, 1940; Pigeon Lake, Port Sheldon, Ottawa Co., no. 939, Aug., 1939; Spring Lake, Ottawa Co., no. 3020, June 21, 1941.

Potamogeton filiformis Pers. var. borealis (Raf.) St. John. — Abundant in Spring Lake, Ottawa Co., Charles Nelson, no. 3023, June 6, 1941; Bill's Lake, Newaygo Co., no. 3387, July 12, 1941.

Potamogeton gramineus var. graminifolius f. myriophyllus (Robbins) House. — Frequent in many lakes of western Michigan. Sandy Bottom Lake, Kent Co., no. 3388, July 7, 1941; Pine Lake, Kent Co., no. 1677, July 18, 1940; Long Lake, Ionia Co., no. 3150, June 30, 1941; Duck Lake, Muskegon Co., July 7, 1941.

Potamogeton interruptus Kitaibel. — A rare pond weed; a single station, Bostwick Lake, Kent Co., no. 943, Nov. 28, 1939.

Potamogeton Berchtoldii var. polyphyllus Morong. — A variation of the very common *P. pusillus* L. Common in Reed's Lake, Kent Co., no. 816, Aug., 1939; Camp Lake, Kent Co., no. 951,

Aug. 4, 1939; Soft Water Lake, Kent Co., no. 673, Aug. 16, 1939; Thomas Lake, Kent Co., no. 2430, Aug. 3, 1941; Little Pine Island Lake, Kent Co., no. 2431, Aug. 10, 1941; Duck Lake, Muskegon Co., no. 3195, July 7, 1941; Bill's Lake, Newaygo Co., no. 3387, July 12, 1941.

Potamogeton Robbinsii Oakes. — Occurs in many lakes of western Michigan. H. J. Oosting, *Pap. Mich. Acad. Sci., Arts, and Letters*, Vol. 15 (1931), reports it as rare, with stations in Muskegon and Ottawa counties. Abundant in Camp Lake, Kent Co., no. 2606, July, 1939; Crooked Lake, Kent Co., no. 5090, Aug. 10, 1942; Ratigan Lake, Kent Co., no. 2607, July, 1939; Big Pine Island Lake, Kent Co., no. 2608, July 10, 1939; abundant in Kimball Lake, Newaygo Co., no. 3567, July 22, 1941.

Potamogeton strictifolius var. rutiloides Fern. — A single station, Green Lake, Allegan Co., no. 3051.

Potamogeton alpinus Balbis var. tenuifolius (Raf.) Ogden. — Distribution general; previously reported in western Michigan by H. J. Oosting, *loc. cit.* Two new stations: Lime Lake, Kent Co., no. 1805, July 29, 1940; Wabasis Creek, Kent Co., nos. 3278–3282, July 11, 1941.

Potamogeton Vaseyi Robbins. — A very rare form, abundant in Pine Lake, Kent Co., no. 1676, July 17, 1940; Scram Lake, Kent Co., no. 6119, July 29, 1944.

Najas marina L. — Brook's Lake, Newaygo Co., no. 2293, Aug. 3, 1940. So far as is known, the occurrence of this plant in Michigan is restricted to this station.

Alisma plantago-aquatica var. parviflorum (Pursh) Farwell. — Occasional in western Michigan; stations at Pine Lake, Kent Co., no. 2188, Sept. 4, 1941.

Alisma plantago-aquatica L. var. brevipes (Greene) Samuelsen. — Wet sand along M–16, near Mona Lake, Muskegon Co., no. 3210, July 7, 1941.

Sagittaria cristata Engelm. — Not abundantly reported. Three new stations were discovered in 1944–45: Crystal Lake, Newaygo Co., no. 3993, Aug. 28, 1941; Scram Lake, Kent Co., no. 6121, July 20, 1944; Provemont, Lake Leelanau, Leelanau Co., no. 6321, Aug. 29, 1944.

Typha angustifolia L. — Not listed for Kent Co. by E. J. Cole, *Flora of Grand Rapids and Vicinity*, 1902. Not abundant.

Along M–16, near Cascade, Kent Co., no. 44; Bear Creek, Robinson Township, Section 23, Ottawa Co., no. 1644, July 12, 1940.

Xyris caroliniana Walb. — A rare form not previously reported. Shore of Angle Lake, Kent Co., no. 1873, Aug. 3, 1940; wet sandy shore of Twin Lakes, Muskegon Co., no. 5860, Sept. 8, 1943.

Festuca octoflora (L.) Beaux. — A single station, Fallasburg Park, Kent Co., no. 920, May 25, 1939.

Festuca ovina var. duriuscula (L.) Koch. — Abundant in dune fields south of Muskegon along Lake Michigan, Muskegon Co., nos. 4509–4968, May 23, 1942.

Holcus lanatus L. — Infrequent in wet marshy places. Springy meadow near Feenville Junction on M–31, Allegan Co., no. 4977, Aug. 4, 1942; East Grand Rapids, Kent Co., no. 6500, July 10, 1945.

Muhlenbergia uniflora (Muhl.) Fern. — Boggy marsh along M–31 in Fife Lake Forest, Grand Traverse Co., no. 3783, Aug. 14, 1941.

Panicum agrostoides Spreng. — Wet sand along M–16, west of Nunica, Ottawa Co., no. 5079, Aug. 8, 1942.

Panicum Ashei Pearson. — Small clumps, in dry oak woods near Grand Haven, Pottawattomie Bayou, Ottawa Co., no. 1349, May 25, 1939.

Panicum Deamii Hitchc. & Chase. — A rare grass, first discovered by C. C. Deam in Indiana. Dr. Jason Swallen, of the National Museum, informs me that the specimens taken at Stony Lake, Oceana Co., nos. 4727, 4784, July 4, 1942, are the first for Michigan.

Panicum Lindheimeri Nash. — Wet sand on shore of Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 5146, Oct. 10, 1942; wet sand along M–16, west of Nunica, Ottawa Co., no. 5078, Aug. 19, 1942.

Panicum meridionale Ashe. — Apparently more common than reported, which may be due to its late appearance. Near shore of Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 5146a, Aug. 19, 1942; on shore of Twin Lakes, Muskegon Co., no. 5867, Sept. 9, 1943; Crockery Lake, Muskegon Co., no. 5882, Sept. 9, 1943.

Poa palustris L. — Marshy shore of Long Lake, Ionia Co., no. 3137, June 30, 1941; marshy southwestern shore of Stony Lake, Oceana Co., no. 4783, July 7, 1942.

Poa trivialis L. — Wet, shady, boggy ravine at Fallasburg Park, Kent Co., no. 4531, June 14, 1942.

Schizachne purpurascens (Torr.) Swallen. — Frequent in dune woods, on the high dunes at Grand Haven, Ottawa Co., no. 4687, June 20, 1942.

Carex annectens Bickn. — Small clearing in a large beech–maple woods on the west belt line of M–114, Walker Township, Section 19, Kent Co., no. 1481, July 10, 1940.

Carex Buxbaumii Wahl. — Large marsh on Maryland Farms, M–21, east of Grand Rapids, Kent Co., no. 824, May 28, 1939; Ely Lake, Allegan Co., no. 1155, June 6, 1942; L. Lake No. 1, Lake Co., no. 1320, June 25, 1940.

Carex concinna R. Br. — Sides of steep, heavily wooded dune hills near Lake Macatawa on the Ottawa and Allegan county line, no. 4928, July 14, 1942. First recorded station for western Michigan.

Carex convoluta Mack. — Numerous throughout southern Michigan. Under trees in wooded ravine at Fallasburg Park, Kent Co., no. 906, May 10, 1939; deep wooded ravine along Scott Creek, Kent Co., no. 1264, June 6, 1940; wooded ravine at Pine Hill, on the Thornapple River, Kent Co., no. 1104, June 17, 1940; low boggy wood, Little Pigeon Creek, Ottawa Co., no. 1388, June 17, 1940; wet woods, Green Lake, Allegan Co., no. 4550, June 18, 1942.

Carex cryptolepis Mack. — All specimens found on wet sandy shores. Morgan Lake, Kent Co., no. 1222, June 9, 1942; Pine Lake, Kent Co., no. 1722, July 20, 1940; Omen Lake, Kent Co., no. 1741, July 20, 1940; Blanche Lake, Newaygo Co., no. 2084, Sept. 1, 1940; Bass Lake, Newaygo Co., no. 3698, Aug. 4, 1941; Dumont Lake, Allegan Co., no. 4641, June 27, 1942.

Carex cumulata (Bailey) Mack. — Single station in rich alluvial soil of Bass River, where it crosses M–50, Ottawa Co., no. 931, July 7, 1940.

Carex Crawei Dewey. — Marshy marly shore of Dumont Lake, Allegan Co., no. 4149, June 27, 1941. Dr. F. J. Hermann informs me that this is the second station for western Michigan. His

only report is for Emmet Co. See his article "The Genus Carex in Michigan," *Am. Mid. Nat.*, 25 (1941): 44, map 105.

Carex Davisii Schwein & Torr. — A rare sedge discovered in the Herbarium of E. J. Cole, Aquinas College; identified by Dr. F. J. Hermann. Indian mounds on Grand River, near Grand Rapids sewage disposal plant, Kent Co.

Carex debilis var. Rudgei Bailey. — Occurs sparingly in southern part of Michigan. Damp woods, Wabasis Lake, Kent Co., no. 1486, July 4, 1940; dune woods along Lake Michigan at Duck Lake, Muskegon Co., no. 3177, July 7, 1941; Brush Lake, Newaygo Co., no. 5384, June 25, 1943; Beaver Island, Emmet Co., no. 2994, May 25, 1942, Sister M. Marcelline Horton.

Carex Emoryi Dewey. — Salt Spring, Pere Marquette Railroad yards south of Grand Rapids, Kent Co., no. 1293, June 6, 1940; Pine Hill, Kent Co., on the Thornapple River at Cascade, no. 2952, June 7, 1941; shore of Stony Lake, Oceana Co., no. 4750, July 7, 1942.

Carex Emmonsii Dewey. — A new station on sandy shore of Ely Lake, Allegan Co., no. 1154, June 6, 1940.

Carex folliculata L. — Boggy woods on Grand River, Plainfield Township, Section 26, Kent Co., no. 2919, May 30, 1941; boggy woods, Tryone Township, Section 13, Kent Co., no. 4894, July 21, 1942; wet woods, Little Pigeon Creek, Ottawa Co., no. 1346, June 28, 1940; dune woods, Wilderness Park, Grand Haven Township, Section 35, Ottawa Co., no. 1350, June 28, 1940; wet woods, Wetmore Lake, Monterey Township, Allegan Co., no. 4676, June 27, 1942. Since this species is fairly common in rich wet woodlands, it is hard to understand why only a few reports and specimens are available.

Carex foenea Willd. — Considered rare some years ago, but new stations have been added until its southern range now extends to Castle Park, Allegan Co. Dune woods, Duck Lake, Muskegon Co., no. 3172, July 7, 1941; dune woods, Ottawa Beach, Ottawa Co., no. 1473, June 28, 1940; dune woods, Castle Park, Ottawa Co., no. 4907, July 14, 1942.

Carex intumescens var. Fernaldii Bailey. — Dense damp woods, Oakfield Township, Section 8, Kent Co., no. 4954, July 22, 1942; wet woods, Little Pigeon Creek, Ottawa Co., no. 914, June 28, 1939; Dumont Lake, Allegan Co., no. 4573, June 27, 1942.

Carex Jamesii Schwein. — A rare sedge from southwest Michigan; reaches its northern limit in the rich low woods near Grand Rapids, on Aquinas College grounds, Kent Co., no. 5287, June 10, 1943; damp woods just west of Green Lake, Allegan Co., no. 4551, June 21, 1942.

Carex laevivaginata (Kukenth.) Mack. — All specimens taken in low rich woods. Scott Creek, Kent Co., no. 1269, June 17, 1940; Little Pigeon Creek, Ottawa Co., no. 1598, July 12, 1940; Dumont Lake, Allegan Co., no. 4624, June 27, 1942.

Carex laricina Mack. — Abundant on boggy shore of Pigeon Lake, Ottawa Co., no. 1469, July 2, 1940; Black Ash Swamp, Byron Township, Section 13, Kent Co., no. 2801a, May 11, 1941.

Carex Longii Mack. — Low oak woods along M–50, just west of Pottawattomie Bayou junction, Ottawa Co., no. 1611, July 12, 1940; along M–16, two miles east of Fruitport, Ottawa Co., no. 3233, July 11, 1941.

Carex leptonervia Fern. — Infrequent throughout western Michigan; three stations given are only ones for counties named. High bluffs at Pine Hill, Thornapple River, Cascade, Kent Co., no. 2314, June 25, 1940; low dune woods, Pigeon Creek, Grand Haven Township, Ottawa Co., no. 541, June 28, 1940; Beaver Island, Emmet Co., May 30, 1942, Sister M. Marcelline Horton.

Carex lenticularis Michx. — Discovered in E. J. Cole's herbarium, Aquinas College; identified by Dr. F. J. Hermann. Along Plaster Creek, Paris Township, Kent Co.; only record for Michigan.

Carex lucorum Willd. — Dune woods near Port Sheldon, Ottawa Co., no. 1541, July 2, 1940; dune woods, Duck Lake, Muskegon Co., no. 3174, July 7, 1941.

Carex molesta Mack. — Rich alluvial woods, Indian mounds on Grand River near Grand Rapids sewage disposal plant, Kent Co., no. 1035, July 16, 1940; deep ravine, Big Pine Island Lake, Kent Co., no. 4842, May 5, 1942; rich wooded valley, Grand Rapids Township, Section 25, Kent Co., no. 818, May 28, 1939.

Carex ormostachya Wieg. — New western Michigan station; low maple woods, Stony Lake, Oceana Co., no. 4701, July 4, 1942.

Carex Peckii Howe. — Two new stations: Beaver Island, Emmet Co., no. 5181, May 30, 1942; Charlevoix, Charlevoix Co., May 30, 1942, Sister M. Marcelline Horton.

Carex projecta Mack. — Rich moist woods. Pratt Lake, Kent

Co., no. 4800, June 1, 1942; Aman Park, Ottawa Co., no. 1569, July 10, 1940; Long Lake, Newaygo Co., no. 3877, Aug. 17, 1941; Dorr, Allegan Co., no. 4575, June 29, 1942.

Carex Richii (Fern.) Mack. — Rare; only other station known is in Kalamazoo Co., reported by C. R. Hanes, of Schoolcraft. Low mucky shore of Little Bostwick Lake, Kent Co., no. 1298, June 24, 1940.

Carex rugosperma Mack. — Dune fields and oak clearings. Along M–16 at Nunica, Ottawa Co., no. 3260, July 7, 1940; cutover land near Spring Lake, Kent Co., no. 4871, July 21, 1942.

Carex Sartwellii Dewey. — A single station. Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 827, May 29, 1940.

Carex siccata Dewey. — Three new stations: dry sterile hillside, Plainfield Township, Section 27, Kent Co., no. 3015, June 20, 1941; bluffs at Richard's farm, Ada Township, Kent Co., no. 2835, June 20, 1941; sand on north side of Penoyer Pond, Newaygo Co., no. 6459, May 25, 1945.

Carex suberecta (Olney) Britton. — Found in sedges sent to Dr. F. J. Hermann from the E. J. Cole herbarium. Tobey Lake, Caledonia Township, Section 23, Kent Co.

Carex Swanii (Fern.) Mack. — Dense low woods, dune woods, and shaded ravines. Woods on Sand Creek south of M–50, Georgetown Township, Ottawa Co., no. 1556, July 10, 1940; low woods on Little Pigeon Creek, Ottawa Co., no. 1393, June 10, 1940; low woods on north side of Pigeon Lake, Ottawa Co., no. 1450, July 2, 1940; dense woods at Wabasis Lake, Kent Co., no. 1485a, July 4, 1940; Dorr, Allegan Co., no. 4588, June 22, 1942; Dumont Lake, Allegan Co., no. 4644, June 27, 1942.

Carex trichocarpa Muhl. — Crooked Lake, Kent Co., June 6, 1939, Sister M. Marcelline Horton. Only western Michigan record.

Carex tonsa (Fern.) Bickn. — Common on sandy wastes, in dunes, and on sandy bluffs. Scott Creek bluffs, Kent Co., no. 1004, May 10, 1940; Grand Rapids Township, Section 2, no. 2886, May 30, 1940; Plainfield Township, Section 16, no. 1256, June 17, 1940; Mona Lake, Muskegon Co., no. 3759, Sept. 10, 1941; Muskegon City, Muskegon Co., no. 4515, May 23, 1942; dune meadow near Montague, Muskegon Co., no. 5062, Aug. 1, 1942; base of dunes on Lake Michigan at Stony Lake, Oceana Co., no. 4765, July 4, 1942; clearings at Brush Lake, Wilcox Town-

ship, Newaygo Co., no. 5380, June 24, 1943; sandy field, Kaleva, Manistee Co., no. 6435, May 1, 1945.

Cyperus diandrus Torr. — Rare. Sandy shores and in wet sand. Wet sand along Grand River at Lowell, Kent Co., no. 4211, Sept. 2, 1941; wet sandy shore, Omen Lake, Kent Co., no. 1747, July 20, 1940; shore of Stearn's Bayou, Ottawa Co., no. 1843, Aug. 1, 1940; wet sand along M–16 at Nunica, Ottawa Co., no. 5076a, July 19, 1942; dry lake bed, Little Blue Lake, Muskegon Co., no. 6761, Sept. 9. 1945.

Cyperus ferruginescens Boeckl. — Sandy shore of Stearn's Bayou, Ottawa Co., no. 1849, Aug. 1, 1940; sandy shore, Pigeon Lake, Port Sheldon, Ottawa Co., no. 1800, Aug. 1, 1940; Wolf Lake, Muskegon Co., no. 4277, Oct. 5, 1941; in mud along Grand River at Lowell, Kent Co., no. 4251, Sept. 28, 1941.

Cyperus Houghtonii Torr. — Very rare, a single record, Houseman and Fountain streets, Grand Rapids, Kent Co., no. 535, July 12, 1939.

Eleocharis compressa var. atrata Svenson. — Wet sandy shores. Bostwick Lake, Kent Co., no. 1304, June 28, 1940; Silver Lake, Kent Co., no. 1409, July 5, 1940; Fruitport, Muskegon Co., no. 3384, July 7, 1940; roadside ditch, Pigeon Lake, Port Sheldon, Ottawa Co., no. 1440, July 2, 1940; shore of Pigeon Lake, Port Sheldon, Ottawa Co., no. 1610, July 20, 1940; beach of Lake Michigan, Cecil Bay, Emmet Co., no. 3845, Aug. 14, 1941; Hamlin Lake, near Baldwin, Lake Co., no. 3647, Aug. 3, 1941; Long Lake, Newaygo Co., no. 3716, Aug. 8, 1941; Beaver Island, Emmet Co., Sister M. Marcelline Horton.

Eleocharis elliptica Kunth. — Marshy shore of Morgan Lake, Kent Co., no. 1221, June 19, 1940; sandy shore of Sandy Bottom Lake, Kent Co., no. 3346, July 11, 1941; interdunal marsh, Castle Park, Allegan Co., no. 5022, Aug. 4, 1941.

Eleocharis melanocarpa Torr. — Although considered very rare when first discovered, four additional stations are now known in Kent Co. and one in Allegan Co.: sand on the edge of a pond one mile east of Knapp Avenue, Grand Rapids Township, Section 2, Kent Co., nos. 1528, 1583, July 8, 1940; shore of Pine Lake, Nelson Township, Section 35, Kent Co., nos. 1698, 1715, July 18, 1940; Allen Road and Clyde Park Blvd., Wyoming Township, Kent Co., no. 4597, June 23, 1942; at edge of a small swale,

one-half mile west of Knapp Avenue, Grand Rapids Township, Section 12, Kent Co., no. 6053, July 20, 1944; Ely Lake, Clyde Township, Allegan Co., no. 1156, June 6, 1940.

Eleocharis Robbinsii Oakes. — Very rare in Michigan; previously reported by C. R. Hanes, West Lake, Kalamazoo Co. I examined a specimen collected by P. E. Hebert, University of Notre Dame, at Buchanan Lake, Berrien Co. My only station is a marsh near Crawford Lake, Kent Co., no. 3333, July 11, 1941.

Eleocharis tricostata Torr. — Woodland swale, two miles east of Fruitport along M–16 on south side of highway, no. 3032, Aug. 7, 1941; Ottawa Co., no. 5027, Aug. 11, 1942. A most unusual find. Dr. Henry K. Svenson, Brooklyn Botanical Garden, writes that it is the first station west of the Atlantic coast.

Rynchospora macrostachys Torr. — Very rare in Michigan, although previously reported in southwestern Michigan. C. R. Hanes, Niles Swamp, Kalamazoo Co., 1933, P. E. Hebert, and Bankson Lake, 1914, Dr. J. A. Nieuwland, formerly of Notre Dame University. New stations are Round Lake, Allegan Co., no. 4984, Aug. 4, 1942; one mile east of Knapp Avenue on M–114, Grand Rapids Township, Section 2, Kent Co., no. 4007, Aug. 28, 1942; McEwan Lake, Kent Co., no. 4187, Sept. 9, 1942; Bass Lake, Newaygo Co., no. 3637, Aug. 3, 1942; Little Blue Lake, Muskegon Co., no. 6736, Sept. 9, 1945.

Scirpus fluviatilis (Torr.) Gray. — Marshy area near Grand River, Grand Rapids sewage disposal plant, Grand Rapids, Kent Co., no. 1630, July 16, 1940.

Scirpus pedicillatus Fern. — Along east belt line, south of Hall St., Grand Rapids, Kent Co., no. 5955, Sept. 14, 1943.

Juncus alpinus Vill. var. rariflorus Hartin. — Sandy shore, Sandy Bottom Lake, Kent Co., no. 3311, July 11, 1941; Long Lake, Newaygo Co., no. 385, Aug. 4, 1941; Duck Lake, Muskegon Co., no. 3185, July 7, 1941.

Juncus balticus var. littoralis f. dissitiflorus Engelm. — Occasional along shore of Lake Michigan. Pigeon Lake, Port Sheldon, Ottawa Co., no. 2301, July 2, 1940; Bear Lake, Muskegon Co., no. 3207, July 7, 1941; Stony Lake, Oceana Co., no. 4703, July 4, 1942.

Juncus biflorus Ell. — Very rare. Wet sandy fields on Boston Avenue, Grand Rapids, Kent Co., no. 2009, Aug. 21, 1940,

and no. 6547, Aug. 10, 1945; shore of Round Lake, Allegan Co., no. 4491, Aug. 4, 1942.

Juncus pelocarpus f. submersus Fassett. — Shallow water on west shore of Crystal Lake, Newaygo Co., no. 3898, Aug. 17, 1941.

Juncus effusus var. decipiens Buch. — Wet sand on east shore, Robinson Lake, Newaygo Co., no. 3742, Aug. 8, 1941. Dr. F. J. Hermann reports this as the first station in the Lower Peninsula.

Juncus Greenii Oakes & Tuckerm. — Gravelly and sandy hillsides; not common. Fallasburg Park, Kent Co., no. 3960, Aug. 17, 1941; wet sand of roadside near Mona Lake, Muskegon Co., no. 5066, Aug. 14, 1942.

Juncus macer f. anthelatus (Wieg.) Hermann. — Occasional in wet areas near lakes. Shore of Dean Lake, five miles northeast of Grand Rapids, Kent Co., no. 2183, Aug. 4, 1940; along banks of Little Pigeon Creek, Ottawa Co., no. 1602, July 12, 1940.

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STUDIES ON PILOBOLUS: *P. KLEINII* AND *P. LONGIPES*

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AMONG the most interesting of the Mucorales are the species of Pilobolus, which occur in nature almost exclusively on the dung of various, mainly herbivorous, animals. Freshly voided horse droppings brought into the laboratory and placed in a covered glass dish on a table near a window will usually show a great number of the sporangiophores of Pilobolus within a week or ten days, and the side and cover of the dish toward the light will be peppered with the almost black sporangia, which are shot off violently toward the region of greatest illumination. In the sixth volume of his *Researches on Fungi* the late A. H. Reginald Buller (1934) devoted over two hundred pages to these fungi; their habits, structure, relation to light, and in particular the mechanism and physiology of the discharge of the sporangia. In the same work W. B. Grove discussed their taxonomy.

According to Grove (1934), the first published description of these fungi was by John Ray, the British botanist, in 1688. The first mention of the discharge of the sporangia appears to be that of Tode (1784), in which he called the fungus "Hutwerfer" and gave to it the generic name Pilobolus, the Greek equivalent of the German name. Gradually the number of species recognized grew until in 1934 Grove listed sixteen, seven of these being somewhat uncertain, in his opinion. Palla (1900) indicated that some of the so-called species are perhaps better regarded as groups of closely related species. This is his opinion particularly of the species groups *crystallinus*, *kleinii*, and *sphaerosporus*. Until the various forms of these groups have been grown under identical conditions in pure cultures, in synthetic culture media or at least in the same lot of culture media, it will be impossible to say with certainty whether they are groups of closely related microspecies or merely ecological forms dependent upon the culture medium and other external factors.

In this paper the two species discussed fall beyond doubt into the two species groups *Pilobolus kleinii* van Tieghem and *P. longipes* van Tieghem. According to Buller, these are the commonest species in Manitoba, whereas Grove and Palla consider *P. kleinii* and its kindred microspecies to be the commonest species in the world. The strains studied by the writer were obtained from freshly dropped horse dung from the horse barns of Michigan State College, East Lansing.

The species of Pilobolus were shown by Egon Bersa (1930) to depend chiefly upon xylan, one of the pentoses, for their carbon source, and upon such substances as peptone, albumen, asparagin, and, best of all, leucine, as the sources of their nitrogen. The undigested pentoses, chiefly xylan, as well as various nitrogenous substances, are present in the dung.

In my experiments the best culture medium, aside from manure, was a water extract of horse manure, strained through cotton to remove the larger particles, to which were added 2 per cent by weight of powdered agar and an equal amount of ground rolled oats, the whole being autoclaved at least an hour at a pressure of 12 to 15 lbs. to kill the numerous spore-producing bacteria present. Manure-extract agar without the rolled oats but with glucose added proved unsuitable for cultivating these fungi.

The vegetative mycelium is submerged in the culture medium, never producing an aerial growth. It is fine, much-branched, tapering, with somewhat granular contents. Like most Mucorales, it is nonseptate, except where a wall is formed to fence off a portion in which the contents have become exhausted. From this actively growing mycelium arise thicker, usually yellowish, unbranched hyphae which seek the surface and emerge as stout, bluntly pointed cylinders whose tips are phototropic, so that they turn toward the source of light. This usually occurs during one day. During the night the basal submerged or superficial portion of this sporangiophore enlarges, becoming separated by a septum into a basal swelling (Pl. I, Fig. 1A), usually having the shape of a turnip or beet, which tapers into a rather straight hypha connecting with the mycelium, and a bulb-shaped or cylindrical trophocyst (Pl. I, Fig. 1B), from whose apex arises directly or at an angle of 45° to 90° the sporangiophore proper (Pl. I, Fig. 1C). The tip of this swells to form the sporangium (Pl. I, Fig. 1F), which is soon cut off by a septum. The

sporangium is filled with a yellow or an orange protoplasm, and the wall at first is colorless and transparent. By early morning the top and side walls have taken on their normal blue-black or black color, and just below the sporangium the apical portion of the sporangiophore enlarges to form the oval or pyriform subsporangial vesicle (Pl. I, Fig. 1 D). The upper end of this vesicle is extended into a more or less conical, usually blunt, columella (Pl. I, Fig. 2), which presses into the lower side of the sporangium, sometimes nearly reaching the upper wall at the center. The spores are numerous and embedded in a gummy substance. They are angular by mutual pressure until they escape from the sporangium and become separated by the dissolving of the gum. At maturity, usually by late forenoon, the sporangium wall dehisces circumscissilely where it comes in contact with the vesicle, probably because of the pressure from the gum surrounding the spores. This gummy mass projects around the opening (Pl. I, Fig. 1 E).

Very shortly after this stage is reached the increased osmotic pressure in the vesicle, sporangiophore, and trophocyst tears the columella from the surrounding circular liplike structure, and the columella, sporangium, and contained spores are shot off, violently propelled by the escaping stream of liquid from the opening at the top of the vesicle. Buller measured the height to which the sporangia might be projected when the illumination was directly from above and showed that for the two species under consideration it occasionally reached six feet, whereas with lateral illumination the sporangia could be thrown eight feet. The top of the sporangium is dry and nonwettable, and does not adhere to objects but rolls over, so that the under side of the columella, wet by the liquid expelled from the vesicle, sticks fast to the object which it may reach. There it dries, and if it be a blade of grass, it is carried into the stomach of an animal eating the leaf. In the alimentary canal the gummy substance in which the spores are embedded dissolves, and the spores are distributed throughout the feces. After these have been set free from the body of the animal, the spores germinate, and if moisture and temperature are favorable, new mature sporangia are shot off within five or six days. Passage through the alimentary canal of an animal is not necessary, however, for the germination of the spores, since these fungi may be grown in culture indefinitely by inoculation with sporangia directly into suitable culture media.

A culture that has begun to produce sporangia may continue to do this for many weeks if not allowed to dry out too much.

The characters upon which specific distinctions are made in the genus Pilobolus are the following:

Color of the sporangium: Bluish black to black in all species except *P. nanus*, in which the mature sporangia are yellow.

Color of spores: Orange in some, pale yellow or colorless in others.

Thickness of spore wall: In *P. longipes* and *P. oedipus* there are a sharply distinct inner wall and a colorless outer wall about 0.8 micron thick.

Shape of spore: Spherical or nearly so as contrasted with decidedly ellipsoidal.

Size of spores: In some they are large and in others small, while in one species spores of all sizes occur in the same sporangium.

Ease of separation of spores from gummy mass containing them.

The shape and size of the trophocyst, of the vesicle, and of the sporangium are also important characters, but these vary much with the medium and with external conditions, as does the total size of the structure.

The chief points of distinction between *P. kleinii* and *P. longipes* (based solely upon the East Lansing strains) are given in Table I.

In general, *Pilobolus longipes* is a larger species than *P. kleinii*. The sporangia average slightly broader, and the surface is finely and shortly aculeate in the former and roughened, rarely aculeate, in the latter. The subsporangial vesicle is oval and a little larger in the former and pyriform in the latter. The trophocysts are the most conspicuous points of difference. In *P. longipes* they are cylindrical or lanceolate in outline, averaging about four times as long as the greatest width, and are more or less horizontal, often superficial when grown on manure but usually submerged in agar cultures. In *P. kleinii* they are shaped like an inverted turnip or are bulblike, being more often upright, about three fourths as wide as tall. They rarely project above the surface of the medium. In both species the basal swellings are quite similar, but are usually a little longer in *P. longipes*. The columella is much smaller and lower in *P. kleinii*.

The spores are subspherical or spherical in *P. longipes* and distinctly ellipsoidal in *P. kleinii*, with a tendency to be broader in the

TABLE I

CHIEF DIFFERENCES BETWEEN *P. KLEINII* AND *P. LONGIPES*

	P. kleinii	*P. longipes*
Sporangium...	Surface finely roughened, rarely aculeate. 45–900 μ broad; average of 393 sporangia 233 μ. Pl. I, Fig. 1F	Surface finely aculeate. 78–720 μ broad; average of 115 sporangia 248 μ. Pl. II, Fig. 1E
Vesicle	Pyriform. 375–945 μ long by 225–705 μ broad (av. 573 × 384). Ratio of breadth to length 0.67. Pl. I, Fig. 1D	Oval. 345–1,050 μ long by 225–750 μ broad (av. 684 × 512). Ratio of breadth to length 0.75. Pl. I, Fig. 3; Pl. II, Fig. 1D
Trophocyst ...	Having shape of inverted turnip; usually upright and submerged in the medium. 105–520 μ tall (av. 353), 165–315 μ wide (av. 278), constricted at basal septum. Pl. I, Fig. 1B	Cylindrical or lanceolate in outline, horizontal or inclined 45 μ, broadest between middle and basal septum, where it is constricted. 300–1,350 μ long (av. 880), 120–315 μ broad (av. 217). Pl. II, Figs. 1B, 2
Basal swelling	Turnip-shaped; hyaline when sporangia are mature. 60–155 μ broad, tapering to a nearly uniform stout hypha at distance of 125–375 μ. Pl. I, Fig. 1A	Turnip-shaped; yellow when sporangia are mature. 105–180 μ broad, tapering to stout hypha at distance of 150–570 μ. Pl. II, Fig. 1A
Columella	40–50 μ high and as wide, or only a little wider, at base; bluntly conical. Pl. I, Fig. 2	53–210 μ high, 105–300 μ wide at base; obtuse at top, upper part almost cylindrical or even slightly narrowed at middle; rarely low-conical. Pl. I, Figs. 3–4
Sporangiophore	420–3,450 μ tall (av. 1,477), 67–120 μ broad near vesicle, 57–105 μ broad near base. Pl. I, Fig. 1C	1,725–8,250 μ tall (av. 4,463), 75–210 μ broad near vesicle, 60–150 μ broad near base. Pl. II, Fig. 1C
Total height ..	3.75–5 mm. (av. 4.4 mm.)	2.0–8.0 mm. (av. 5.2)
Spores	Ellipsoidal, orange, thin-walled. 7.9–20.9 μ by 7.0–13.7 μ. Average in larger sporangia (above 570 μ), 13.2 × 11.4 μ, in sporangia 550 μ and smaller, 13.2 × 8.6 μ, yet in one sporangium 600 μ broad averaging 12.2 × 7.5 μ. Pl. II, Fig. 4	Subspherical to spherical, orange yellow, wall double, a distinct thin inner wall and a transparent outer wall 0.8 μ thick. 7.4–16.8 × 7.2–14.9 μ (av. 13.5 × 12–15). Pl. II, Fig. 3

larger sporangia of the latter than in the smaller ones. There is a marked difference in the spore walls; in *P. kleinii* they show only one distinct layer. In *P. longipes*, on the other hand, besides the distinct inner wall there is a transparent outer wall about 0.8 μ thick. It is possible that the latter is soluble, for in sporangia that have stood many hours or a few days in droplets of condensation water on the side of the flask in which the culture was growing one finds difficulty in distinguishing it. In color there are some differences. In the mature sporangiophore the basal swelling of *P. longipes*, below the trophocyst, is packed with very small granules, so that in transmitted light it looks dark but in reflected light appears orange yellow. In *P. kleinii* at this stage it is practically empty. The protoplasmic collar at the lower end of the subsporangial vesicle is large in the latter species and sometimes almost closes the opening to the sporangiophore. It is orange-colored. It is much less evident in *P. longipes*. In both species shortly before the sporangium is mature the orange granules of the vesicle may form a beautiful network over the whole inner surface of the wall, but at maturity the vesicle is practically clear. The wall of the vesicle, sporangiophore, and trophocyst of *P. longipes* at full maturity has a pale yellow tinge which is lacking in *P. kleinii*.

A striking difference is shown when the two species are treated with chloriodide of zinc solution. In my *P. kleinii* no part of the fruiting structure or of the vegetative mycelium takes on a violet or purplish coloration except a very narrow ring at the opening of the vesicle, where the abscission of the columella has left a slightly thickened lip. In my *P. longipes* this lip is much more heavily colored by the reagent and, in addition, the lower two thirds or three quarters of the wall of the sporangiophore, and the walls of the trophocyst, the basal swelling, and even of the vegetative mycelium are stained a purple brown or violet brown. Apparently the chitin content of the walls is not sufficient in this species, except in the upper portion of the sporangiophore, to prevent the color reaction by the cellulose or cellulose-related substance composing a large part of the wall. It would be interesting to determine whether the same condition is true for the large forms of *P. longipes*, whose fruiting bodies are sometimes ten times as tall and are much thicker than those in the form I had. Possibly other species from various regions may vary in their reaction. Klein (1872) observed the staining of the cell wall of Pilobolus on

treatment with iodine dissolved in KI solution. He reported the wine-red coloration of the cell wall of the whole sporangiophore and trophocyst, basal swelling, and vegetative mycelium in some tests or only of the lower portion of the sporangiophore in others. Probably he was dealing with different species. He did not have pure cultures of his fungi, for in some of his fungi he had round and in others ellipsoidal spores, and the latter were orange-colored and large or almost hyaline and small. He was inclined to the belief that all were perhaps merely forms or different stages of development of the same species. Unfortunately he did not indicate upon which of these forms he made his tests with iodine solution. He apparently had at various times *P. crystallinus* (Weber) Tode, *P. roridus* (Bolt.) Pers., *P. kleinii* van Tieghem, and *P. sphaerosporus* Palla.

Although on the average the spores of *P. kleinii* are broader in proportion to their length in the larger sporangia, it is interesting to note that in a culture from a single sporangium the sizes of the sporangia produced are extremely variable. A number of such cultures were made, being inoculated with single sporangia of different sizes for each culture. The results are shown in Table II.

TABLE II

Relation of Size of Sporangium Used as Inoculum to Size of the Sporangia Produced in the Cultures (*P. kleinii*)

Diameter of sporangium used as inoculum	*Range of size in the sporangia produced*	*Average size of sporangia produced*
(*a*) 120 μ	90–360 μ	213 μ
(*b*) 150 μ	82–315 μ	166 μ
(*c*) 180 μ	60–450 μ	225 μ
(*d*) 338 μ	60–420 μ	195 μ
(*e*) 345 μ	60–405 μ	146 μ
Av. 231 μ	...	180 μ (204 sporangia)

Transfers of sporangia of (*a*), (*c*), (*d*), and (*e*) into soyka dishes containing autoclaved horse manure gave sporangia of various sizes as follows: (*a*) 60–308 μ, av. 192 μ; (*c*) 99–420 μ, av. 259 μ; (*d*) 97–420 μ, av. 240 μ; (*e*) 45–430 μ, av. 215 μ.

From the foregoing data it is apparent that for *P. kleinii* the size of sporangium used as inoculum has no close correlation with the size of the sporangia produced by the resulting cultures.

In *P. longipes* also the sporangium size of the culture varied greatly

from the size of the sporangium used as inoculum. Thus in one culture the sporangia produced ranged from 187 to 615 μ, with an average of 373 μ.

In a culture of *P. kleinii* in manure extract and ground rolled oats and agar an abundant production of sporangia occurred for several weeks. There was early a small bacterial colony which grew until the agar was pretty well covered. The culture was examined about three months after it was started. There were no zygospores. The lateral branches of the vegetative mycelium, instead of tapering to points, were swollen terminally and produced terminal and intercalary chlamydospores with a pale brown wall about 2 μ thick. Sometimes clusters of these chlamydospores resembling bunches of grapes occurred near the trophocysts, arising from the same hyphae. Possibly exhaustion of the medium or toxic action of the bacteria was responsible for the production of the chlamydospores.

Sexual reproduction has rarely been observed in Pilobolus. In 1888 Zopf described and illustrated zygospore formation (Pl. III, Figs. 2–5) in *P. kleinii* (which he erroneously identified as *P. crystallinus*). He found this only where the fungus was parasitized by *Pleotrachelus fulgens* Zopf or by *Syncephalis sp.* In his illustrations he shows several zygospores in various stages of development, one of them with the two suspensors arising from the same hypha. He mentions this occurrence particularly in his text (Pl. III, Fig. 2, of the present paper). This would mean that the species is homothallic. According to Blakeslee (1904), Dr. Roland Thaxter observed these zygospores but did not publish on them. In 1906 Morini described and figured zygospores in *P. borzianus* Morini, but did not give any clue whether the species is homothallic or heterothallic. In 1931 Hans Krafczyk reported zygospore formation (Pl. III, Fig. 6) in agar cultures of *P. crystallinus* (Weber) Tode. These were produced only when two strains of opposite sex were mated. The species is definitely heterothallic.

I was fortunate enough to obtain one lot of fresh horse manure upon which sporangiophores of *P. kleinii* arose in great abundance, with no signs of attack by Pleotrachelus or by Syncephalis. In the upper two or three millimeters of the manure large numbers of the zygospores were produced. In another lot of manure two months later a few sporangiophores were produced, and several trophocysts and other organs were infected by *Pleotrachelus fulgens* (Pl. III,

Figs. 8–9). In this culture, too, a large number of zygospores appeared. In the suspensors and supporting hyphae of a few of these were numerous spherical to ellipsoidal sporangia of an Olpidium-like fungus, 7–10 μ in longer dimension (Pl. III, Fig. 7). Some perforated the Pilobolus wall by a single short exit tube, but since no zoospores could be observed the identity of the fungus could not be determined. In some of the sporangia instead of thin walls the walls were about 0.7 μ thick. The contents of the sporangia, both thin- and thick-walled, were yellowish but the walls were hyaline.

In none of the cultures made in agar combinations were zygospores produced, whether inoculation was made by a single sporangium or by many sporangia or by mating cultures originated from sporangia of different sizes and origin, or even by attempting to cross *P. kleinii* and *P. longipes*. In none of the manure cultures or agar cultures of the latter species could I find zygospores.

The zygospores (Pl. III, Fig. 1) of *P. kleinii* are more or less spherical, sometimes longer in the vertical direction, sometimes flattened, so that the equatorial direction is the greater. The measurements of thirty-four mature or fully grown zygospores ranged from 53 to 150 μ in both directions, the average dimension being 97 and 88 μ for height and equatorial diameter respectively. When the zygospores are immature, the outer wall is smooth and almost colorless, and the interior of the zygospore contains many small or a few large yellow drops. At zygospore maturity the outer wall, the original wall of the united gametangia, is ruptured and forms flakes of various sizes which give the zygospore a roughened appearance. The interior wall of the mature zygospore is 2 to 4.4 μ thick and is pale brown, as are the walls of the pyriform suspensors. In the mature spore the oil drops have disappeared, and the contents are finely granular.

The suspensors are caught around one another at the slender bases and at the contact surfaces various finger-like lobes and branches wind around the supporting hyphae, sometimes interlocking like the fingers of clasped hands. In my opinion this structure serves to hold the suspensors tight at the bottom. At first they are relatively slender and parallel, but later bow out until the tips meet at an obtuse angle, the bodies of the suspensors rapidly becoming thicker. The gametangia are then cut off near the tips by cross septa, and soon the flattened mutual wall between the greatly enlarged cells dissolves

out and the zygospore is produced. At the beginning the latter is enclosed only in the walls of the gametangia but immediately an inner wall begins to be deposited. In the meantime the suspensors have become pyriform and have resumed contact with each other for their full length. No two zygospores were found in which the entanglements at the bases of the suspensors were alike. As shown in some of Zopf's illustrations, this entanglement may be scarcely more than a simple twining once of the two hyphae or a very complicated system of interlocking fingers may be developed.

In the specimens examined there was no evidence to indicate whether *P. kleinii* is heterothallic or homothallic. The cultures in sterile manure and in manure-extract agar did not produce any zygospores, whether the inoculum was one sporangium or a large number of sporangia.

Several attempts were made to obtain cultures by inoculating a zygospore of *P. kleinii* into sterilized manure and into agar made up with extract of manure with various additions. Other fungi as well as bacteria, evidently contaminants on the surface of the zygospore, grew, but no trace of Pilobolus appeared in over two months, by which time the cultures had become too dry for growth of this fungus.

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PLATES I–III

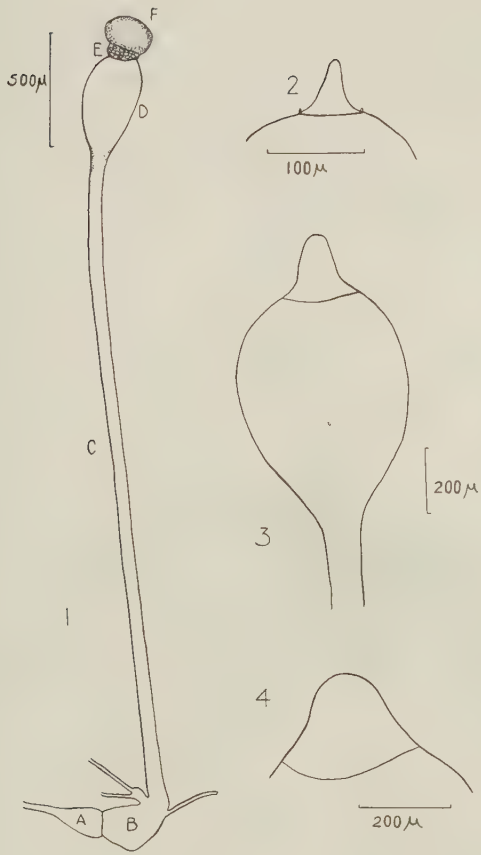

Fig. 1. *Pilobolus kleinii* van Tieghem: *A*, basal swelling; *B*, trophocyst; *C*, sporangiophore; *D*, subsporangial vesicle; *E*, mass of spores embedded in gum at base of partially opened sporangium; *F*, sporangium

Fig. 2. *P. kleinii*, columella and upper portion of subsporangial vesicle

Fig. 3. *P. longipes* van Tieghem, subsporangial vesicle and more typical form of columella

Fig. 4. *P. longipes*, broader, less typical, form of columella

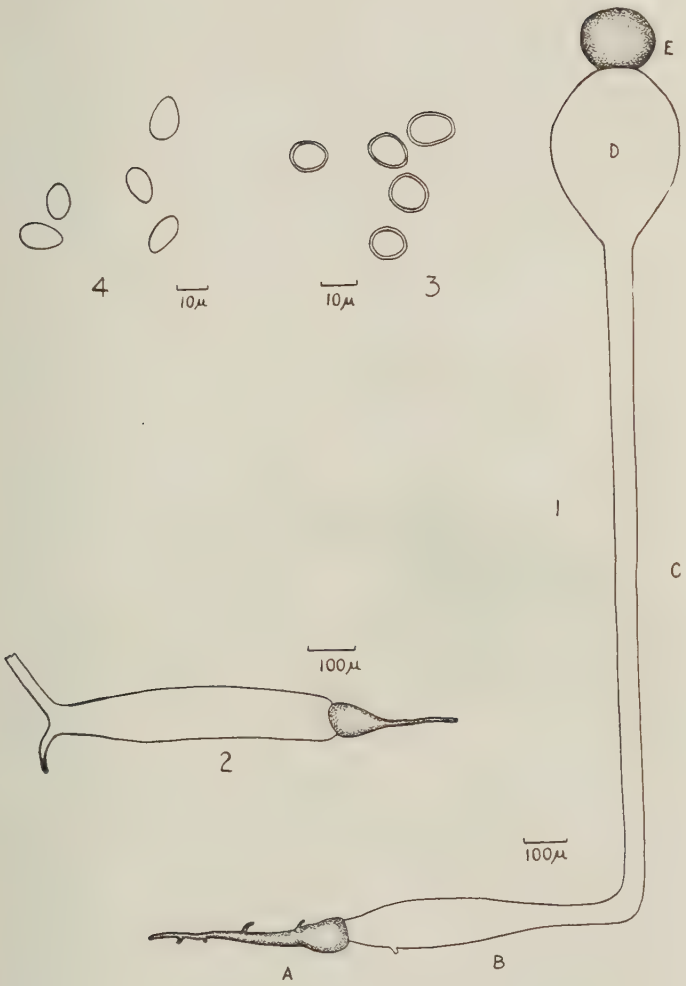

FIG. 1. *P. longipes; A*, basal swelling; *B*, trophocyst; *C*, sporangiophore; *D*, subsporangial vesicle; *E*, sporangium

FIG. 2. *P. longipes*, another trophocyst and basal swelling

FIG. 3. *P. longipes*, spores showing thick walls and spherical shape

FIG. 4. *P. kleinii*, spores showing thin walls and ellipsoidal shape

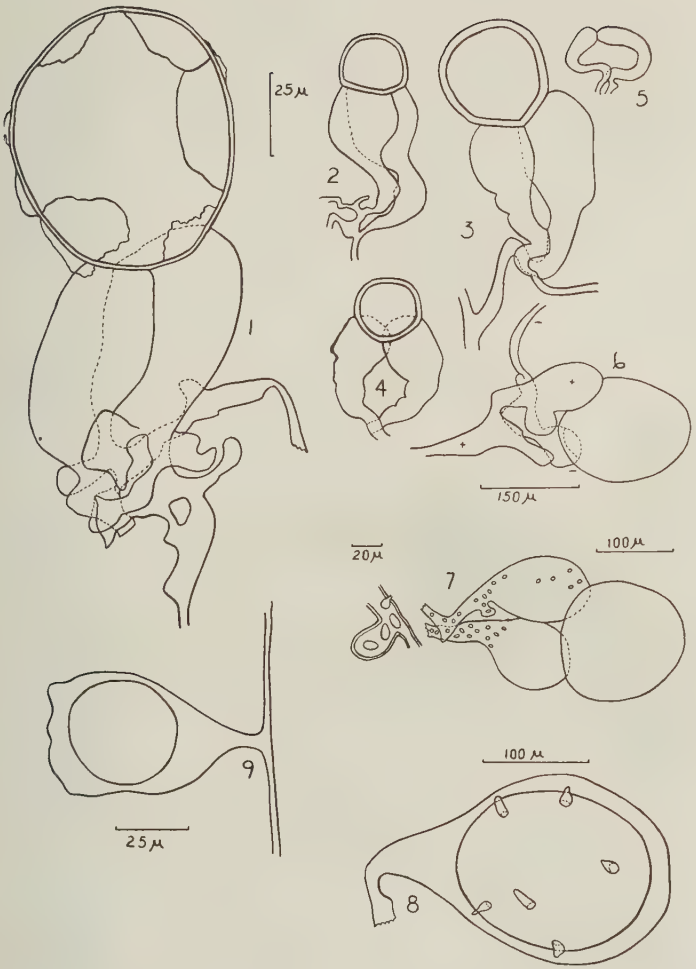

Fig. 1. *P. kleinii*, zygospore

Figs. 2–5. *P. kleinii*, after Zopf. In Figure 2 the homothallic origin of the zygospore is shown

Fig. 6. Zygospore of *P. crystallinus* Tode, after Krafczyk

Fig. 7. Zygospore of *P. kleinii* showing zoosporangia of an Olpidium-like fungus in the suspensors and supporting hyphae

Fig. 8. *Pleotrachelus fulgens* Zopf in trophocyst of *P. kleinii*

Fig. 9. Young zoosporangium (?) of *Pl. fulgens* in a heaped-up mass of the protoplasm in a sporangiophore of *P. kleinii*

ADDITIONS TO AN ANNOTATED LIST OF THE HIGHER PLANTS OF THE REGION OF DOUGLAS LAKE, MICHIGAN. III *

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IN 1909 the University of Michigan established the Biological Station at Douglas Lake, Cheboygan County, Michigan. As stated in the first paper in this series, in the same year F. M. Loew began to list the plants in the vicinity of the station in Cheboygan and Emmet counties, the two northernmost counties of the Lower Peninsula. In 1911 F. C. Gates, who was then serving as an agent of the Michigan Biological and Geological Survey, brought the number of species up to 530. This list was published in the *Fourteenth Report of the Michigan Academy of Science* (1912), pp. 46–106.

Upon the return of F. C. Gates to the station in 1915 and the coming of J. H. Ehlers in 1916 a program for the active study of the higher plants of the region was instituted. In 1925 they published in the *Papers* an annotated list of the plants, and in 1928 and 1931 made additions to it.[1]

It was the original intention of the authors to publish additions every five years, but circumstances, including the retirement of Dr. Ehlers in 1938, prevented the carrying out of the plan. Fortunately, it is now possible to present a third list of additions, which increases the number of species and varieties to 1,226. This list, covering the first thirty years of systematic botanical work in the two counties mentioned, brings to a close our joint reports on the flora of the Douglas Lake region.

* Contribution 472 from the Department of Botany of Kansas State College and Paper 840 from the Department of Botany of the University of Michigan.

[1] *Papers* 4 (1924) : 183–284. 1925; 8 (1927) : 111–120. 1928; 13 (1930) : 67–88. 1931.

The period of our botanical investigations has witnessed great changes in the activities of this region. At the beginning there was a thriving lumber industry, but at present little wood other than that used for fuel or for poles is being cut. Great areas of cut-over land, good, medium, and bad, that were once devoted tc farming are now abandoned, and, where cultivation was thorough, are growing up in grass. In other places forests of aspen, beech–maple, pine, or white cedar are intruding upon them. Instead of numerous small streams one now finds ditches and drainage canals, many of which are dry most of the time. The winding sand roads through the woods have been replaced by macadam or gravel roads, although there are a few black-top ones. Horse-drawn vehicles have yielded to automobiles. Originally no fruits were cultivated, but there is now some sporadic raising of small fruits such as raspberries and strawberries, and a few apple orchards. The amount of fruit picked from wild areas still exceeds that grown under cultivation; it consists mostly of blueberries and blackberries, and small quantities of cranberries. All of the towns have diminished in size. There has been some increase in the number of recreational camps, as well as in tourists' accommodations during the summer and in hunting facilities during the late fall. Many trees have been planted on University properties and a few elsewhere. Forest fires, the former bane of the region, have virtually been eliminated.

An interesting case history of the difficulties of the city of Cheboygan between 1890 and 1940, written by D. L. Gibson, entitled *Socio-Economic Evolution in a Timbered Area in Northern Michigan*, was published in 1944 by the Michigan Agricultural Experiment Station as Technical Bulletin No. 193.

Our data are now grouped under five headings instead of the customary four. They are as follows: (1) new records for the region; (2) new records for Emmet County; (3) new records for Cheboygan County; (4) verifications of Emmet County records by C. W. Fallass and C. H. Swift; and (5) new records made by the senior author, 1938–45. The families are arranged as in the other papers of the series and numbered accordingly.

In a study of the grasses of the Douglas Lake region L. H. Harvey published in the *Papers*, 25 (1939) : 43–46. 1940, with permission, a number of records which would otherwise now be given for the first time. His name is added to each repeated record.

In this list the letters "E." and "C." at the extreme right indicate Emmet and Cheboygan counties.

New Records for the Region

In this section are included plants found in the region for the first time since the publication of the original list and its two additions and also species for which identifications have since been made.

Phylum LEPIDOPHYTA

1. Lycopodiaceae (Club Moss Family)

Lycopodium inundatum L. C.
Sandy shore of Vincent Lake, 1933; bog mat at Little Lake Sixteen, 1936; spreading rapidly.

Phylum ANTHOPHYTA

2. Butomaceae

Butomus umbellatus L. E.
Near Alanson, by V. J. Wulff, 1938, July.

6. Sparganiaceae (Burreed Family)

Sparganium androcladum (Engelm.) Morong (*S. americanum androcladum* (Engelm.) Fernald & Ames) E.
In Crooked River at Alanson, 1934.

9. Potamogetonaceae (Pondweed Family)

Potamogeton angustifolius Berchtold & Presl C.
Maple Bay, Douglas Lake, 1933; Black Lake outlet, 1934.

Potamogeton epihydrus Raf. C.
Lancaster Lake, 1933. Rare.

Potamogeton heterophyllus f. terrestris Schlecht. E.C.
A common form in low-water years, but not previously mentioned by name.

Potamogeton obtusifolius Mertens & Koch E.
Shallow water of Carp Lake, 1933.

Potamogeton robbinsii Oakes E.C.
Crooked River at Alanson, 1935; Pigeon River near Mullet Lake, 1937. Rare.

Potamogeton strictifolius rutiloides Fernald C.
A variety additional to the species from the outlet of Black Lake, 1932.

10. Liliaceae (Lily Family)

Maianthemum canadense pubescens E.C.
The pubescent form occurs with the glabrous form in various pineland areas in both counties.

12. Pontederiaceae (Pickerelweed Family)

Heteranthera dubia (Jacq.) MacM. E.C.
Black Lake near outlet, 1933; Crooked River near Alanson, 1938.

16. Xyridaceae (Yelloweyed Grass Family)

Xyris montana Ries. C.
Mat at Little Lake Sixteen, 1936.

18. Juncaceae (Rush Family)

Juncus alpinus rariflorus Hartm. E.C.
This variety, determined by F. J. Hermann, was formerly listed as *Juncus alpinus insignis*. Frequent on wet gravelly and sandy shores.

Juncus effusus compactus Lejeune & Courtois E.
Swampy banks of Crooked River, 1938. (A variety added.)

Juncus militaris Bigel. C.
Little Lake Sixteen, forming floating islands in the lake and later in the mat on the east side.

Juncus pelocarpus Mey. C.
Border of Penny Lake, 1932; sandy shore of Vincent Lake, 1935; mat of Little Lake Sixteen, 1936.

Juncus vaseyi Engelm. C.
Sandy flat, Penny Lake, 1933.

30. Cyperaceae (Sedge Family)

Carex normalis Mackenzie C.
Wooded shore of Burt Lake, 1930.

Carex setacea ambigua (Barratt) Fernald C.
Roadside ditch along road to Cheboygan, 1932.

Eleocharis obtusa (Willd.) Schultes C.
Muddy banks of Nigger Creek, near Mullet Lake, 1938.

Scleria verticillata Muhl. E.
Bog margin at Cecil Bay, 1938.

31. Poaceae (Grass Family)

Festuca octoflora Walt. C.
Along a path at the Biological Station, probably brought in mud by automobiles. Ehlers, as recorded in L. H. Harvey, 1940.

Eragrostis poaeoides Beauv. C.
Ballast of Michigan Central Railroad, Mackinaw City, 1937, L. H. Harvey, in Harvey, 1940.

Phragmites communis f. repens E.
With long runners (to 43 feet) on clayey-rocky flats of Lake Michigan east of Cecil Bay, 1937, L. H. Harvey, in Harvey, 1940.

Agropyron subsecundum (Link) Hitchc. (*A. caninum* of our previous list) C.
Sandy shore, Straits of Mackinac.

Lolium temulentum L. C.
Cheboygan dumping ground, 1938, L. H. Harvey, in Harvey, 1940.

Agrostis palustris Huds. (*A. maritima* Lam.) (This name was used for *Agrostis alba* L. in our previous list.) C.
Cheboygan dumping ground, 1935. Ehlers, as recorded in Harvey, 1940.

Sporobolus cryptandrus (Torr.) A. Gray C.
Along U. S. Highway 23 near Mackinaw City, 1937, L. H. Harvey, in Harvey, 1940.

Beckmannia syzigachne (Steud.) Fernald E.
Bordering a cold spring at Alanson, 1932. Ehlers, as recorded in Harvey, 1940. New also to Michigan (fide Harvey).

Phalaris canariensis L. C.
Cheboygan dumping ground, 1938, L. H. Harvey, in Harvey, 1940.

Phalaris arundinacea picta L. C.
Grassy banks of Cheboygan River at Cheboygan, 1934.

Panicum lindheimeri Nash. C.
Marshy shore of Duncan Bay, 1938. (Determined by J. R. Swallen.)

PANICUM MILIACEUM L. C.
Cheboygan dumping ground, 1933.

35. IRIDACEAE (Iris Family)

IRIS VIRGINICA L. E.C.
Swamps at head of Burt Lake, 1931; Duncan Bay; Indian River; Cecil Bay.

45. ORCHIDACEAE (Orchid Family)

CALYPSO BULBOSA (L.) Oakes E.C.
Shaded banks of Duncan Bay, 1931, by R. L. Walp, under pines in Big Stone Bay, 1933.

HABENARIA DILATATA MEDIA (Rydb.) Ames E.
Margin of bog in Cecil Bay, 1933. (A variety of the species previously listed as *Limnorchis dilatata.*)

80. MORACEAE (Mulberry Family)

CANNABIS SATIVA L. C.
Weed in barnyard at Ingleside, 1924.

104. EUPHORBIACEAE (Spurge Family)

GALARRHOEUS ESULA (L.) Rydb. E.
Sandy soil, along U. S. Highway 31 south of Carp Lake, 1935.

CHAMAESYCE HUMISTRATA (Engelm.) Small E.
Waste ground in Mackinaw City and in Bayview, 1931.

108. HYPERICACEAE (St. John's Wort Family)

HYPERICUM CANADENSE L. E.
Marsh around French Farm Lake, 1930.

132. BRASSICACEAE (Mustard Family)

ERUCASTRUM GALLICUM (Willd.) O. E. Schulz C.
Cheboygan dumping ground, 1933.

140. SALICACEAE (Willow Family)

SALIX CANDIDA × S. BEBBIANA C.
In a Larix bog across the Cheboygan–Levering road north of Mud Lake, 1935.

146. Chenopodiaceae (Goosefoot Family)

Atriplex patula L. C.
Cheboygan dumping ground, 1936. Varieties *hastata* (L.) Gray and *littoralis* (L.) Gray; both in the same place, 1933.

147. Polygonaceae (Smartweed Family)

Polygonum douglasii Greene E.
Sandy shore of Lake Michigan near Cross Village, 1932.

Polygonum stevensii Brenckle E.
Beach at Cecil, Aug. 22, 1936 (F. C. G. 19582). (Determined by Brenckle in 1941.)

151. Primulaceae (Primrose Family)

Lysimachia nummularia L. C.
Low ground, and submerged in Mud Creek, inlet into Carp Lake, 1935.

Steironema quadriflorum (Sims) Hitchc. C.
Grassy shore of Black Lake at Fairview, 1937.

169. Boraginaceae (Borage Family)

Anchusa officinalis L. C.
Abandoned house at Riggsville Corners, 1935.

Symphytum officinale L. C.
Waste ground, Cheboygan, 1934.

172. Oleaceae (Olive Family)

Ligustrum vulgare L. E.
Shrub, escaping along Grand Rapids and Indiana Railroad (now Pennsylvania Lines) near Kegomic, 1930.

178. Scrophulariaceae (Figwort Family)

Castilleja pallida septentrionalis (Lindl.) Gray E.
Bogs west of Cecil, 1936.

Verbascum blattaria albiflorum Ktze. E.
Roadside west of Pellston, 1931. A variety (better, a form) of the species previously recorded.

182. Orobanchaceae (Broomrape Family)

Anoplanthus uniflorus (L.) Endl. (Orobanche, Aphyllon, Thalesia) C.
At margin of coniferous woods, east shore of Duncan Bay, 1931.

185. Lentibulariaceae (Bladderwort Family)

Utricularia clandestina Nutt. C.
Livingston Bog, 1932, by G. E. Nichols.

191. Lamiaceae (Mint Family)

Hedeoma hispida Pursh C.
Roadside in Inverness Township, 1935.

Lycopus virginicus L. C.
Shore of Burt Lake west of Carp Creek, 1930.

192. Rosaceae (Rose Family)

Rosa blanda hermanni Erlanson C.
Ice rampart, Duncan Bay, 1931. (Determined by E. W. Erlanson.)

Rosa rubiginosa L. C.
Ballast of Michigan Central Railroad at Mill Creek, southeast of Mackinaw City, 1930.

Rubus peracer Bailey. *Gentes Herbarum*, 5 : 492–494. 1944. C.
"Bank of stream, near University of Michigan Biological Station, *Bailey 788*."

Rubus parviflorus Nutt. of our earlier list is now separated into *R. parviflorus hypomalacus* Fernald, previously listed, and *R. parviflorus bifarius* Fernald. The latter, from a limestone outcrop at Mill Creek, 1930 and later years, is new to the list. E.C.

Schizonotus sorbifolius (L.) Lindl. (*Sorbaria sorbifolia* (L.) A. Brown.) E.
Escaped from cultivation. Roadside two miles east of Bliss, 1931.

193. Malaceae (Apple Family)

Amelanchier: The amelanchiers of our previous list have been further collected by J. H. Ehlers and reëvaluated by K. M. Wiegand as follows:

AMELANCHIER BARTRAMIANA × LAEVIS Wiegand? C.
East side of Smith's bog.

AMELANCHIER LAEVIS Wiegand C.
Aspens south of Douglas Lake and Smith's bog region.

AMELANCHIER LAEVIS × STOLONIFERA Wiegand E.C.
Sandy ground vicinity of the Biological Station and Cecil — Big Stone Bay region.

AMELANCHIER HURONENSIS Wiegand E.C.
Aspens in the vicinity of the Biological Station and openings in coniferous woods in Big Stone Bay region.

AMELANCHIER HURONENSIS × LAEVIS Wiegand (probably) C.
Aspens near the Biological Station and Smith's bog.

AMELANCHIER HURONENSIS × STOLONIFERA Wiegand? C.
Sandy ridge near the Biological Station.

AMELANCHIER STOLONIFERA Wiegand E.C.
Jack-pine plains south of Burt Lake and dune region of northwestern Emmet County.

CRATAEGUS LUCORUM Sarg. C.
Jack-pine forest, 1930.

194. PRUNACEAE (Plum Family)

PRUNUS AMERICANA Marsh. C.
Sandy soil at Yoeman's, Colonial Point, Burt Lake, 1932.

198. CASSIACEAE (Senna Family)

GLEDITSIA TRIACANTHOS INERMIS Willd. E.
Hedgerow along U. S. Highway 31 between Brutus and Alanson 1932.

199. FABACEAE (Bean Family)

LATHYRUS LATIFOLIUS L. E.C.
Roadside and railroad ballast north of Alanson, 1934. Cultivated and escaping at the Biological Station.

LATHYRUS TUBEROSUS L. E.
Roadside along U. S. Highway 31 south of Carp Lake, 1935.

VICIA DASYCARPA Ten. E.
Roadside along U. S. Highway 31 south of Carp Lake, 1936.

215. Lythraceae (Loosestrife Family)

Lythrum salicaria L. C.
Grassy swamp at outlet of Cheboygan River, 1933.

261. Aesculaceae (Buckeye Family)

Aesculus hippocastanum L. C.
Cultivated in Cheboygan.

262. Aceraceae (Maple Family)

Acer saccharum rugelii Rehd. C.
Woods along north shore of Burt Lake, 1931. (Additional to the species.)

269. Juglandaceae (Walnut Family)

Carya (probably C. glabra (Mill.) Spach.) E.
Planted along a road east of Round (Lark) Lake; not fruiting, 1933.

270. Betulaceae (Birch Family)

Betula pumila L. C.
In Chamaedaphne bog at Little Lake Sixteen, 1936. The variety *glandulifera* Regel is also present in the same area.

279. Caprifoliaceae (Honeysuckle Family)

Lonicera morrowii A. Gray E.
Escaping from cultivation. Along Pere Marquette Railroad near quarry at Bayview, 1931.

Lonicera tatarica L. E.
Escaping from cultivation. Along Pere Marquette Railroad near quarry at Bayview, 1931. Previously recorded in cultivation.

Symphoricarpos occidentalis Hook. C.
At Michigan Central Railroad station at Topinabee, 1934.

Symphoricarpos racemosus pauciflorus Robbins E.C.
Previously recorded as the species from jack-pine plains south of Burt Lake. Sandy woods edging Lake Michigan at Lookout Point.

287–300. Compositae

287. Helianthaceae (Sunflower Family)

Helianthus hirsutus Raf. C.
Cheboygan dumping ground, 1933.

Rudbeckia laciniata L. E.C.
Banks of Sturgeon River south of Burt Lake, 1931; roadside ditch at southwestern corner of Emmet County, 1942.

288. Ambrosiaceae (Ragweed Family)

Ambrosia trifida integrifolia (Muhl.) Gray C.
Cheboygan dumping ground, 1935. (The species has previously been recorded from Emmet County.)

293. Asteraceae (Aster Family)

Aster paniculatus bellidiflorus (Willd.) Burgess E.C.
Low ground in aspens along Maple River west of Douglas Lake, 1938.

296. Anthemidaceae

Matricaria suaveolens (Pursh) Buchenau E.C.
Cheboygan and dumping ground, 1936; along a road on the north shore of Carp Lake, 1935.

298. Carduaceae (Thistle Family)

Centaurea cyanus L. C.
Cheboygan and the city dumping ground, 1935.

300. Lactucaceae (Lettuce Family)

Sonchus arvensis L. C.
Waste ground and fallow field, Cheboygan and vicinity, 1931 and later.
Also var. *glabrescens* Gunth., Graebner and Wimmer, in the same places, 1933 and later.

New Records for Emmet County

Since the publication of the previous papers the species listed below have been found in Emmet County also.

Phylum PTERIDOPHYTA

11. Polypodiaceae

Dryopteris phegopteris (L.) C. Chr. E.C.
In Thuja woods along Pickerel Lake, 1933.

Phylum ANTHOPHYTA

6. Sparganiaceae (Burreed Family)

Sparganium americanum Nutt. E.C.
Crooked River, 1937; also in the Cecil Bay region, 1938.

9. Potamogetonaceae (Pondweed Family)

Potamogeton foliosus Raf. E.C.
Carp and French Farm lakes, 1933; a pond in Wilderness State Park.

Potamogeton heterophyllus f. myriophyllus (Robbins) Morong E.C.
French Farm Lake, 1935.

22. Naiadaceae

Naias flexilis (Willd.) R. & S. E.C.
Crooked River, 1932, and Sucker Creek, 1934.

30. Cyperaceae (Sedge Family)

Carex projecta Mackenzie E.C.
Big Stone Bay, 1924, and Lark Lake area, 1933.

Scirpus subterminalis Torr. E.C.
French Farm Lake, 1930 and 1935.

31. Poaceae (Grass Family)

Agrostis capillaris L. E.C.
Wet road at Wycamp Lake, 1931.

Brachyelytrum erectum (Schreb.) Beauv. E.C.
Thickets along Crooked River near Alanson, 1932. F. C. G. 17204. L. H. Harvey 418, 1937, in Harvey, 1940.

Leersia oryzoides (L.) Sw. E.C.
Crooked River at Alanson, 1934. J. H. E. 5649. L. H. Harvey 510, 1937, in Harvey, 1940.

PANICUM TSUGETORUM Nash E.C.
"Widespread on old vegetated sand dunes southeast of Sturgeon Bay. Harvey 683, 1938."

140. SALICACEAE (Willow Family)

SALIX CORDATA Muhl. E.C.
Foredune ridge at Cecil, 1931.

169. BORAGINACEAE (Borage Family)

CYNOGLOSSUM BOREALE Fernald E.C.
Open woods at Trail's End, Cecil Bay, 1930; north of Harbor Springs, 1937.

194. PRUNACEAE (Plum Family)

PRUNUS ALLEGHANIENSIS DAVISII W. F. Wight. E.C.
Small tree in piny aspens east of Pellston, 1930.

224. HALORAGIDACEAE (Water Milfoil Family)

MYRIOPHYLLUM VERTICILLATUM PECTINATUM Wallr. E.C.
Crooked River at Alanson, 1937.

287. HELIANTHACEAE (Sunflower Family)

HELIANTHUS SUBRHOMBOIDEUS Rydb. (= *Helianthus rigidus* (Cass.) Desf.) E.C.
In aspens west of Douglas Lake, 1934.

293. ASTERACEAE (Aster Family)

ASTER LINDLEYANUS T. & G. E.C.
Piny aspens east of Pellston, 1931.

NEW RECORDS FOR CHEBOYGAN COUNTY

Since the publication of the previous papers the species listed below have been found in Cheboygan County also.

6. SPARGANIACEAE (Burreed Family)

SPARGANIUM ACAULE (Beeby) Rydb. E.C.
Muddy shores and shallow water, Penny Lake, 1932.

12. Pontederiaceae (Pickerelweed Family)

Pontederia cordata L. E.C.
Black Lake near its outlet, 1932.

30. Cyperaceae (Sedge Family)

Eleocharis rostellata Torr. E.C.
Margin of Twin Lakes, 1933, H. A. Gleason; also shore of Munro Lake.

Rynchospora capillacea Torr. E.C.
Sandy shore of Lake Huron southeast of Mackinaw City, 1938.

Rynchospora fusca (L.) Ait. f. E.C.
Wet sand, Vincent Lake, 1936.

31. Poaceae (Grass Family)

Bromus tectorum L. E.C.
Railroad ballast and near-by roads, L. H. Harvey 519, 1937, in Harvey, 1940.

Calamovilfa longifolia (Hook.) Hack. E.C.
Dunes along Duncan Bay, L. H. Harvey 427, 1937, in Harvey, 1940.

Elymus virginicus L. E.C.
Depression in aspens north of Tower, 1937, L. H. Harvey 239, in Harvey, 1940.

35. Iridaceae (Iris Family)

Sisyrinchium angustifolium Mill. E.C.
Shore of Lake Huron east of Duncan Bay, 1930.

45. Orchidaceae (Orchid Family)

Lysias hookeriana (A. Gray) Rydb. (*Habenaria hookeriana*) E.C.
Coniferous woods along Lake Huron east of Cheboygan, 1931, and in Benton Township, 1934.

104. Euphorbiaceae (Spurge Family)

Tithymalopsis corollata (L.) Kl. & Garcke (*Euphorbia corollata* L.) E.C.
Camping place near Penny Lake, 1931.

126. Papaveraceae (Poppy Family)

Papaver rhoeas L. E.C.
Roadside south of Indian River, 1930.

132. Brassicaceae (Mustard Family)

Arabis holboellii Hornem. E.C.
Sandy shore of Lake Huron southeast of Mackinaw City, 1934.

Barbarea stricta Andrz. E.C.
Shores of Lake Huron northwest of Cheboygan and of Mill Creek, 1936.

190. Verbenaceae (Verbena Family)

Verbena stricta Vent. E.C.
Roadside near Penny Lake, 1932; Green Star Trail, Inverness Township, 1934.

199. Fabaceae (Bean Family)

Lathyrus maritimus (L.) Bigel. E.C.
Although previously credited to Cheboygan County on the basis of plants persistent from seeds planted at the Biological Station, it grows naturally along Lake Huron north of Pries' Landing.

Robinia pseudoacacia L. E.C.
Planted behind the Biological Station and freely escaping.

276. Ammiaceae (Carrot Family)

Conium maculatum L. E.C.
Roadside along U. S. Highway 23 northwest of Cheboygan, 1930.

287. Helianthaceae (Sunflower Family)

Bidens frondosa L. E.C.
Wet sand, north shore of Burt Lake, 1923.

288. Ambrosiaceae (Ragweed Family)

Ambrosia trifida L. E.C.
Colonial Point, 1932; Cheboygan and vicinity.

293. Asteraceae (Aster Family)

Solidago gillmani (A. Gray) Steele. E.C.
Shores of Lake Huron east of Cheboygan, 1938.

Solidago houghtonii T. & G. E.C.
Sandy beach of Lake Huron at Pries' Landing, 1931.
Solidago ohioensis Riddell E.C.
Sandy beach of Lake Huron at Pries' Landing, 1931.

296. Anthemidaceae

Tanacetum huronense Nutt. E.C.
Sandy beach of Lake Huron east of Cheboygan, 1931.

298. Carduaceae (Thistle Family)

Carduus crispus L. E.C.
Roadside north of Douglas Lake, 1933.

Verifications of Emmet County Records by Fallass and Swift

In the list published by the authors in 1925 some of the records for Emmet County (indicated by "E *") were based solely on an unpublished list of Emmet County plants by Fallass and Swift. During the years subsequent to the appearance of "Additions I" and "Additions II" the presence of the following species in Emmet County has been verified by collections by our own.

Phylum CALAMOPHYTA

2. Equisetaceae (Horsetail Family)

Equisetum palustre L. E.C.
Crooked River at Alanson, 1934.

Phylum ANTHOPHYTA

6. Sparganiaceae (Burreed Family)

Sparganium eurycarpum Engelm. E.C.
Crooked River at Alanson, 1932.
Sparganium minimum Fries. E.C.
Shallow water, French Farm Lake, 1935.

9. Potamogetonaceae (Pondweed Family)

Potamogeton pectinatus L. E.C.
French Farm Lake, 1930; Crooked River at Alanson, 1933.
Potamogeton perfoliatus L. E.C.
Crooked River at Alanson, 1938.

30. Cyperaceae (Sedge Family)

Carex lupulina Muhl. E.C.
Maple River thickets west of Pellston, 1931.
Carex tribuloides Wahl. E.C.
West of Pellston, 1931.

31. Poaceae (Grass Family)

Agropyron tenerum Vasey E.C.
Aspens west of Douglas Lake, 1931.

45. Orchidaceae (Orchid Family)

Liparis loeselii (L.) Richards E.C.
Desiccated beach pool, Cecil Bay, 1936.
Pogonia ophioglossoides (L.) Ker. E.C.
Desiccated beach pool, Cecil Bay, 1936.
Spiranthes gracilis (Bigel.) Beck E.C.
Edge of Lower O'Neal Lake, 1934.
Spiranthes romanzoffiana Cham. (*S. strictum*) E.C.
Edge of beach pool, Sturgeon Bay dunes, 1930.

60. Ranunculaceae (Buttercup Family)

Ranunculus longirostris Godron (*Batrachium trichophyllum* (Chaix) F. Schultz) E.C.
Sturgeon Bay and Crooked River at Alanson.

132. Brassicaceae (Mustard Family)

Brassica nigra (L.) Koch E.C.
Rye field east of Trail's End, Cecil Bay, 1936.

133. Caryophyllaceae (Pink Family)

Agrostemma githago L. E.C.
Field west of Pellston.

169. Boraginaceae (Borage Family)

Lithospermum officinale L. E.C.
Wooded park at Mackinaw City, 1933.

172. Oleaceae (Olive Family)

Fraxinus pennsylvanica Marsh. E.C.
Shore of Wycamp Lake, 1931.

178. Scrophulariaceae (Figwort Family)

Mimulus geyeri Torr. E.C.
Bank of Maple River south of the dam, 1936.
Mimulus ringens L. E.C.
Along Carp River at Cecil, 1931.

185. Lentibulariaceae (Bladderwort Family)

Utricularia resupinata B. D. Greene E.C.
Northwest part of West Lake, north of Carp Lake, G. E. Nichols, 1934.

192. Rosaceae (Rose Family)

Geum canadense Jacq. E.C.
Beech–maple forest west of Pellston, 1931.
Potentilla canadensis L. E.C.
Aspens west of Pellston, 1931.
Rubus canadensis L. E.C.
Margin of beech–maple forest, McGulpin Point, 1934.

237. Vitaceae (Grape Family)

Parthenocissus quinquefolia (L.) Planch E.C.
Woods west of Pellston, 1930.

277. Cornaceae (Dogwood Family)

Cornus amomum Mill. E.C.
Sandy ridge at Cecil Bay, 1931.

278. Rubiaceae (Madder Family)

Galium circaezans Michx. E.C.
Woods west of Pellston, 1930.

279. Caprifoliaceae (Honeysuckle Family)

Lonicera glaucescens Rydb. E.C.
Piny aspens west of Maple River, 1934.

283. Campanulaceae (Bellwort Family)

Lobelia siphilitica L. E.C.
Along Maple River, 1931.

293. Asteraceae (Aster Family)

Solidago altissima L. E.C.
Aspens west of Douglas Lake, 1938.

Solidago caesia L. E.C.
Wooded dunes south of Cross Village, 1930.

Solidago serotina Ait. E.C.
Aspens west of Douglas Lake, 1938.

New Records Made by the Senior Author, 1938–45

Although travel was greatly restricted during most of the years after the retirement of Dr. Ehlers, nevertheless a few additions were made to the flora of the Douglas Lake region. To keep them separate from the work of the joint authorship they are given in the list below.

NEW RECORDS

Ulmus pumila L. E.C.
Planted at the Biological Station about 1936; has been dwindling for five years. Planted at Oden Fish Hatchery.

Plantago arenaria W. & K. E.
Ballast of Pennsylvania Railroad Lines at Kegomic, 1945. F. C. G. 21568.

Thymus serpyllum L. E.
Waste area along U. S. Highway 31 north of Conway, 1945. F. C. G. 21571.

Galium wirtgenii F. Schultz E.
Waste area along U. S. Highway 31 north of Conway, 1945. F. C. G. 21570. (First present about 1941.)

ADDITIONS FROM CHEBOYGAN COUNTY

AGROPYRON SMITHII Rydb. E.C.
Roadside in Hebron Township, 1942. F. G. G. 21431.

SALIX CANDIDA × DISCOLOR E.C.
Larix bog north of Mud Lake, 1940. F. C. G. 21157.

CONFIRMATION OF RECORDS BY FALLASS AND SWIFT
(Changes from E* to E)

EPIFAGUS VIRGINIANA (L.) Bart. E.C.
Beech–maple woods at Bayview, 1942. F. C. G. 21459.

ASTER NOVAE-ANGLIAE L. E.C.
Boggy ground bordering a lake north of Pleasant View, 1941. F. C. G 21352.

TABLE I

SUMMARY OF PHYLA

Phyla	Emmet County	Cheboygan County	Total		
			Families	Genera	Species and varieties
9. Pteridophyta	17	33	4	14	33
10. Calamophyta	11	13	1	1	14
11. Lepidophyta	7	9	2	2	10
13. Strobilophyta	12	12	2	8	12
14. Anthophyta	891	1053	115	435	1157
Monocotyledoneae	(297)	(347)	(19)	(111)	(379)
Dicotyledoneae-Axiflorae	(302)	(354)	(50)	(180)	(396)
Dicotyledoneae-Calyciflorae	(292)	(352)	(46)	(144)	(382)
Totals	938	1120	124	460	1226

The following families have 25 or more species in the region:

"Compositae" .. 129	Rosaceae 43	Fabaceae..... 28
Cyperaceae 123	Orchidaceae..... 38	Polygonaceae .. 27
Poaceae 112	Lamiaceae 30	Salicaceae 26
Brassicaceae 43	Ranunculaceae .. 29	

The largest genus is Carex, with 91 species.

A POSTGLACIAL PLANT SUCCESSION AT ANN ARBOR, MICHIGAN, DATING FROM THE HIGHEST LAKE MAUMEE LEVEL*

ETHEL B. HANSEN

INTRODUCTION

DURING the oscillating retreat of the last continental ice sheet new land areas were constantly being laid bare to the invasion of plants. To determine the identity of these pioneers and the plant successions that developed in the denuded areas is of importance, for it serves not only to unite the present vegetation with that of the past, but also to facilitate the interpretation of relict communities and postglacial climates.

An early postglacial deposit located in the roadside bank along Plymouth Road about one-quarter mile northeast of Calvary Evangelical Church (formerly known as Broadway Chapel), Ann Arbor, Michigan (Fig. 1), offered an opportunity for such an investigation. Although many of the fossils were poorly preserved and fragmentary, they provided the basis for a reconstruction of the biota in the Ann Arbor area as well as for a study of the development of the vegetation after the fall in level of the highest glacial Lake Maumee.

ACKNOWLEDGMENTS

For kindly criticism I am indebted to Professor H. H. Bartlett, who found the deposit and directed me in the conduct of the investigation. I wish to thank those who made the following identifications: the fossil Mollusca, by Mr. Calvin Goodrich; the deer antler, by Dr. Lee R. Dice; the snail eggs and the surface Mollusca, by Dr. A. F. Archer; the moss, by Dr. W. C. Steere; the algae, by Dr. G. W. Prescott. To Dr. Gladys F. West I am grateful for

* Papers from the Department of Botany of the University of Michigan, No. 515.

assistance in making the collections. But above everyone else I am under obligation to the late Dr. Frank Leverett, who interpreted the glacial geology of the region and wrote a detailed memorandum, illustrated by a map, on the position of the ice border.

GEOLOGICAL HISTORY

During the waning stage of the last or Wisconsin ice sheet the ice margin was formed into prominent lobes occupying the basins of the Great Lakes. This lobation was favored by the fact that the ice was thinner on the highlands and disappeared from them faster than in the basins of the Great Lakes between them.

Three large lobes of the Wisconsin ice sheet, the Huron–Erie, the Saginaw, and the Michigan, encroached upon the Southern Peninsula of Michigan. As the ice sheet halted in the northward retreat of its border, moraines were formed. These were arranged in loops adjacent to and lying concentrically with the borders of the lobes. The Huron–Erie and the Saginaw were the only lobes which touched the Ann Arbor quadrangle. As the Saginaw lobe of the glacier withdrew from the northwestern part of this quadrangle, it exposed part of the interlobate moraine formed between the Saginaw and the Huron–Erie lobes. On the Huron–Erie ice border were formed in succession the Fort Wayne moraine and the outer ridge of the Defiance moraine. Drainage was then down the Huron River and along the ice front to the Raisin River and southward into a pre-Defiance bay of glacial Lake Maumee at Tecumseh, Michigan. An outwash apron, on which the University of Michigan campus now stands, and the gravel deposits east of the Huron River in the north part of Ann Arbor were laid down at this time. As the Huron–Erie lobe shrank to the inner ridge of the Defiance moraine, the Huron and Raisin rivers continued to discharge into glacial Lake Maumee (Russell and Leverett, 1915).

After this period the ice border shrank eastward far enough to permit the extension of Lake Maumee to Ypsilanti and along a narrow bay or estuary up the Huron River Valley to Ann Arbor (Fig. 1). The backwaters of the highest stage of glacial Lake Maumee filled the Huron River Valley in the Ann Arbor area as far as the 800-foot contour line and thus formed an estuary extending over what is now the lowland along the Ann Arbor railroad in the northern part of the city. While it was flowing into the end of the estuary,

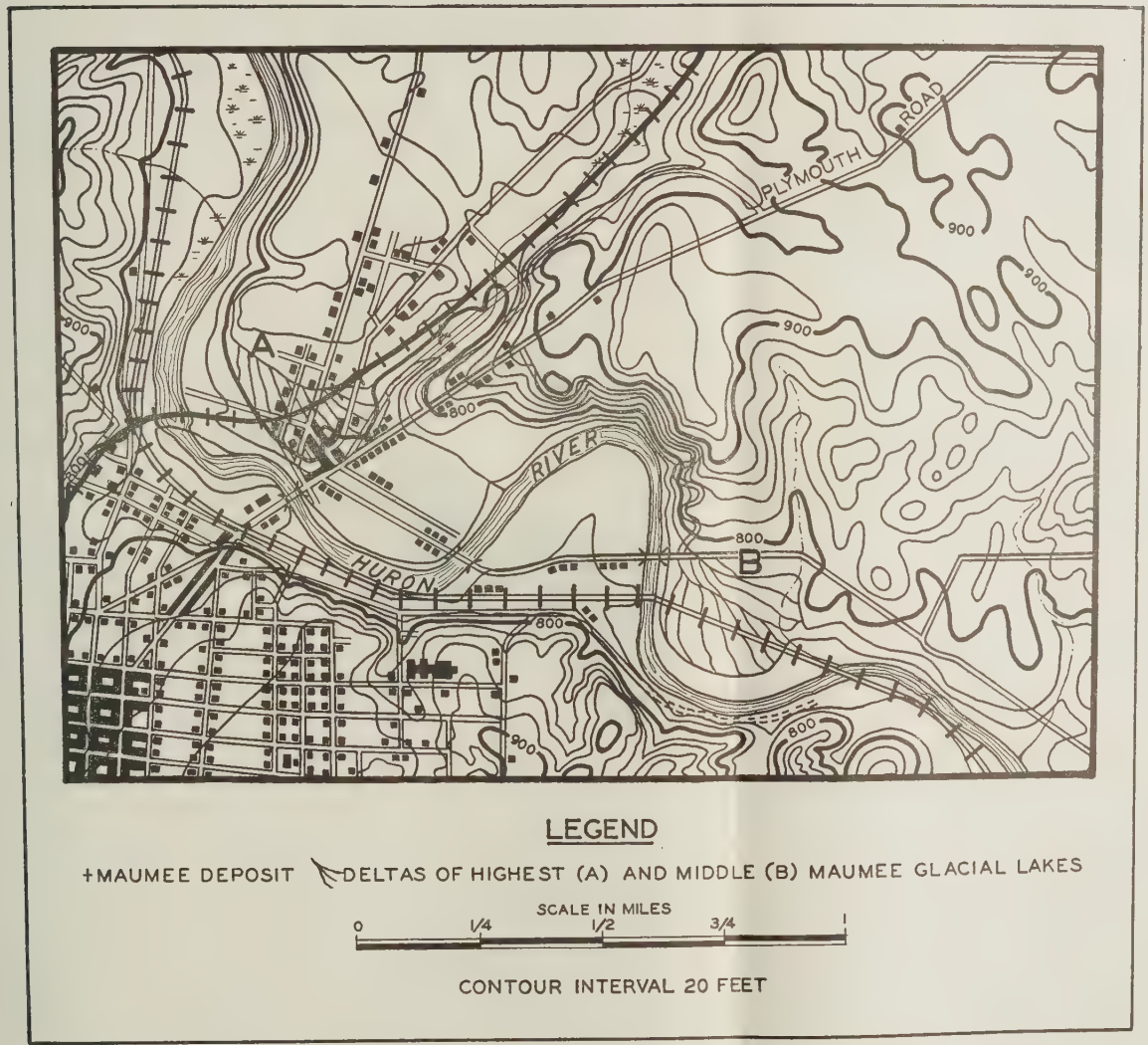


FIG. 1. Map of Ann Arbor, showing location of the Maumee deposit near the railroad and of the deltas of the highest and the middle Maumee glacial lakes

the Huron River built a delta of the highest glacial Lake Maumee (*A* in Fig. 1).

Eventually, as the ice melted further, Lake Maumee found a lower outlet than that through Fort Wayne, which led across the "Thumb" of Michigan (Leverett and Taylor, 1915). The level of the estuary was lowered sufficiently to allow the lime-laden waters of the springs to seep down the gravel bank of the old Huron River into the bordering lower land at the site of the deposit and form a layer of tufa about two feet thick upon the Lake Maumee clay surface, at an elevation of 788 feet. There followed a succession of alternating layers of peat and tufa which built up the terrace bench, from 788 feet to 797½ feet, in which the fossil remains were preserved (Pls. I–II).

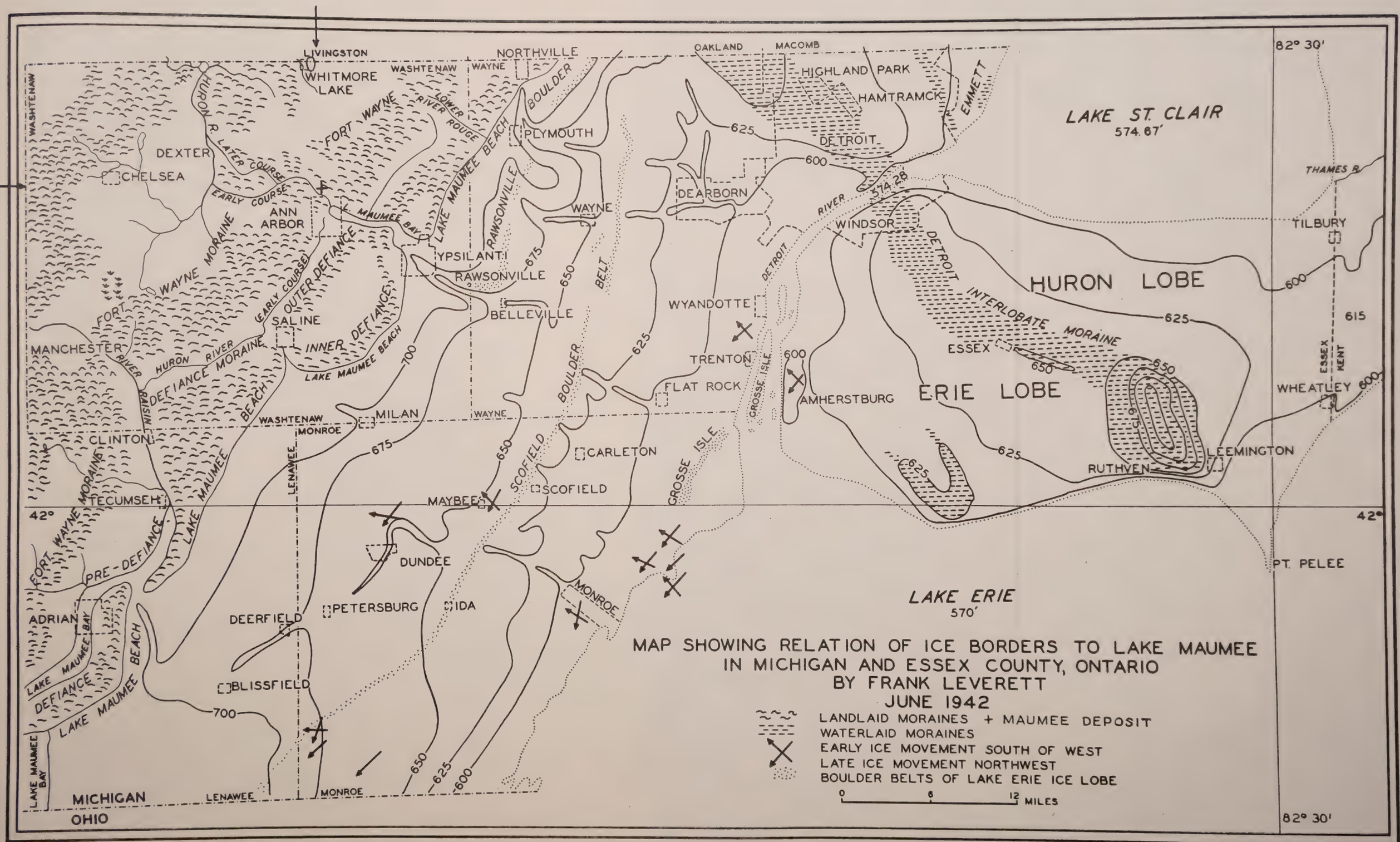
Dr. Leverett was greatly interested in the deposit described in this paper and personally prepared the map which is reproduced as Figure 2. A memorandum by him which accompanied the map is here repeated almost verbatim. The position of the ice border during the time the tufa deposit was being developed has been worked out not only in the southeastern part of Michigan, but also in the adjoining part of Ontario. The Birmingham moraine marks the position on the west side of the Huron ice lobe from Imlay City southward past Romeo, Rochester, and Birmingham. Between Birmingham and Detroit there is an interlobate moraine formed as the joint product of the Huron and the Erie ice lobes. This is called the Detroit Interlobate, and it has been traced by W. H. Sherzer across the Ontario Peninsula from Windsor, Ontario, to the north bluff of Lake Erie near Leamington in a southeastward course; the Huron lobe stood on its northeastern side while the Erie lobe stood on the southwestern side. The Huron lobe covered about thirty miles of the north bluff of Lake Erie east of Leamington, Ontario, as determined by Leverett, and forced the Lake Erie lobe to stay within the limits of the Erie bluff. A moraine forming the east border of the Huron lobe starts at the Lake Erie shore at Cedar Springs in Kent County and runs northward past Ridgetown and Highgate, and is traceable in that course through Middlesex County past Mt. Brydges. This correlates closely with the Birmingham moraine of southeastern Michigan. It is a matter of note that the Huron lobe formed a definite easily mappable moraine all around its border. In this respect it is decidedly in contrast with the Erie lobe.

The Erie lobe is represented in Wayne and Monroe counties in Michigan by bouldery strips in a featureless plain. These are not continuous, but are found in patches and short strips, as indicated by Sherzer in his maps of Wayne and Monroe counties. The outer boulder belt is called the Rawsonville moraine, since it is developed in the vicinity of that hamlet. The inner belt is called the Scofield moraine, from a small village situated on it in northern Monroe County (Fig. 2).

DETAILED DESCRIPTION OF THE DEPOSIT

The site of the tufa and peat deposit is shown in Plates I and II. It was exposed during the excavating for widening what is known as the Plymouth Road. The fresh exposure showed a series of highly irregular layers and lenses of peat interlarded with much more calcareous tufa than peat, the whole resting upon an impervious layer of Maumee Lake clay which formed a definite spring level. At the top of the sloping road cut is a railroad, and beyond the railroad the gently sloped surface of the terrace extends for one hundred and fifty feet from the edge of the road. Since higher levels on the same slope showed only gravel, it is obvious that the peat and tufa had been formed on the spring-fed sloping seepage surface inclined toward the level of the Plymouth Road. A thorough investigation of the deposit required digging a trench (Pl. V, Fig. 2) into the bank at a right angle to the road as far as possible without undermining the railroad right of way, the edge of which is marked by the line of fence posts shown in Plate I. On the other side of the railroad the deposit was explored by digging a series of postholes in line with the trench. The trench and postholes enabled the course of the more or less continuous strata to be followed. They were undulating and only slightly inclined up the slope, and their positions were determined by measurement and plotted to provide the basis for Figure 3. The figure is more useful than any number of photographs of the side walls of the trench would have been, because the trench was so narrow that photographs would have been too oblique and distorted.

In general, the sloped surface of the road bank did not indicate any intelligible trend of the layers. This was, of course, because the original Maumee Lake clay surface, upon which the organic deposits had been formed, had itself been hummocky and irregular.



MAP SHOWING RELATION OF ICE BORDERS TO LAKE MAUMEE
IN MICHIGAN AND ESSEX COUNTY, ONTARIO
BY FRANK LEVERETT
JUNE 1942

LANDLAID MORAINES + MAUMEE DEPOSIT
WATERLAID MORAINES
EARLY ICE MOVEMENT SOUTH OF WEST
LATE ICE MOVEMENT NORTHWEST
BOULDER BELTS OF LAKE ERIE ICE LOBE

0 6 12 MILES

Fig. 2

TABLE I

SAMPLES, FROM BOTTOM TO TOP, AT MIDDLE OF TRENCH IN WHICH FOSSIL SEEDS AND MOLLUSCA WERE FOUND

Sample No.	Depth				Layer shown in Figure 3	Embedding material
	From		To			
	ft.	in.	ft.	in.		
19	..	..	..	..	...	Surface
18	0	4	1	4	7c and 6e	Tufa and peat
17	1	4	1	10	7c	6 in. tufa
16	1	10	2	1	7c	Coarse tufa, no peat
15	2	1	2	6	7c and 6d	5 in. peat, some tufa
14	2	6	2	10	6c and 7c	4 in. tufa, some peat
13	2	10	3	2	7b and 6c	4 in. tufa, some peat
12	3	2	3	7	7b and peat lens	5 in. tufa, some peat
11	3	7	3	11	7b	4 in. coarse tufa
10	3	11	4	2	7a and 6b	3 in. coarse tufa, some peat
9	4	2	4	6	7a	4 in. coarse tufa
8	4	6	5	0	7a	6 in. coarse tufa
7	5	0	5	5	7a	5 in. coarse tufa
6	5	5	6	0	6a and 7a	7 in. peat and tufa
5	6	0	6	3	4	3 in. variegated peat
4	6	3	6	6	4	3 in. variegated peat
3	6	6	6	11	4	5 in. variegated peat
2	6	11	7	3	4	4 in. peat
1	7	3	9	0	2 and 3	Blue clay and coarse tufa

A number of photographs of the freshly beveled bank (Pls. I–II) show the highly irregular nature of the bedding when the deposit was sliced off along a quite precise inclined plane.

The vertical cut, which was carried back into the bank as the end face of the trench, was photographed when the trench was only begun. It is very informative, indeed, and is shown in Plates III and IV. The stratification was much clearer, and the chief layers were numbered in the hope that some of them could be traced continuously into the bank as the trench was extended (Pl. V, Fig. 2). Figure 3 shows the result of tracing the layers in the lateral wall of the trench and through the postholes.

The correlation of the layers in the trench and postholes was clearly indicated by their texture and color. The posthole highest up the slope was at an elevation of 808 feet 4 inches. At this point the Maumee clay base of the deposit was 4 feet below the ground

TABLE II

VERTICAL DISTRIBUTION OF FOSSIL SEEDS, SPORES, LEAVES, AND WOOD

Abbreviations: l, leaves; o, spores; s, seeds; t, trichoblast; w, wood

Number of sample in deposit (see Table I)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Fungi	.	o	o	.	.	.	.	.	.	.	o	o	o	o	o	o	.	.
Sphagnum	.	o	o	l	l	l	l	l	.	.	.	.	.	.	.	.	.	.
Musci	.	.	.	o	o	.	o	.	.	.	o	o	.	.	o	.	.	o
Amblystegium sp	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	l
Polypodiaceae	.	o	o	.	o	o	o	o	.	.	o	o	o	o	o	o	o	o
Pteris aquilina L.	.	.	.	.	.	.	.	.	.	.	o	o	.	.	.	.	.	o
Pinus Strobus L.	.	.	.	.	.	.	.	.	.	.	.	.	.	w	.	w	.	.
Larix laricina (DuRoi) Koch (stem)	.	w	w	w	w	.	.	w	.	.	w	w	.	w	w	w	.	.
Larix laricina (DuRoi) Koch (root)	.	.	.	w	w	.	.	.	.	.	w	.	.	w	.	.	.	.
Picea canadensis (Mill.) BSP.	.	w	.	w	.	.	.	.	.	.	w	.	.	.	s	.	.	.
Picea mariana (Mill.) BSP.	.	w	w	w	.	.	w	w	.	.	w	.	.	w	w	w	.	.
Abies balsamea (L.) Mill.	.	w	w	w	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Scirpus sp.	.	s	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Carex retrorsa Schwein.	.	s	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Quercus alba L.	.	.	.	.	.	.	.	.	.	.	.	.	.	w	.	.	.	.
Nymphaeaceae	.	t	.	t	.	.	.	t	.	.	.	.	.	.	.	.	.	.
Rubus idaeus var. aculeatissimus [C. A. Mey.] Regel & Tiling (?)	.	s	.	.	.	.	.	.	.	.	s	.	.	.	s	.	.	.
Rubus occidentalis L. (?)	.	.	.	.	.	.	.	.	.	.	s	.	.	.	.	.	.	.
Rubus allegheniensis Porter (?)	.	.	s	.	.	.	.	.	.	.	s	.	s	.	s	.	.	s
Zanthoxylum americanum Mill.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	s	.	.	.
Vitis vulpina L.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	s
Fraxinus nigra Marsh.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	w	.	.	.
Sambucus canadensis L.	.	.	.	.	.	.	.	.	.	s	s	.	s	s	s	.	.	.
Sambucus racemosa L.	.	.	.	.	.	.	.	.	.	.	.	s	.	s	.	.	.	.

surface, at an elevation of 804 feet 4 inches. For 106 feet from the edge of the road the depth of the Maumee Lake clay varied slightly, but rose sharply in the remaining 44 feet up the original hill slope (Pl. V, Fig. 1).

The calcareous tufa layers above the lowest were vaguely but very discontinuously marbled or stratified, having more or less discoloration dependent upon the peat content. It was impossible to show this condition in Figure 3, because of the small size, the irregularity, and the variability of the minor peaty tufa lenses.

PLANT REMAINS FOUND IN THE DEPOSIT

Although specific identification of the fossils was highly desirable, it was often impossible because of their fragmentary or distorted

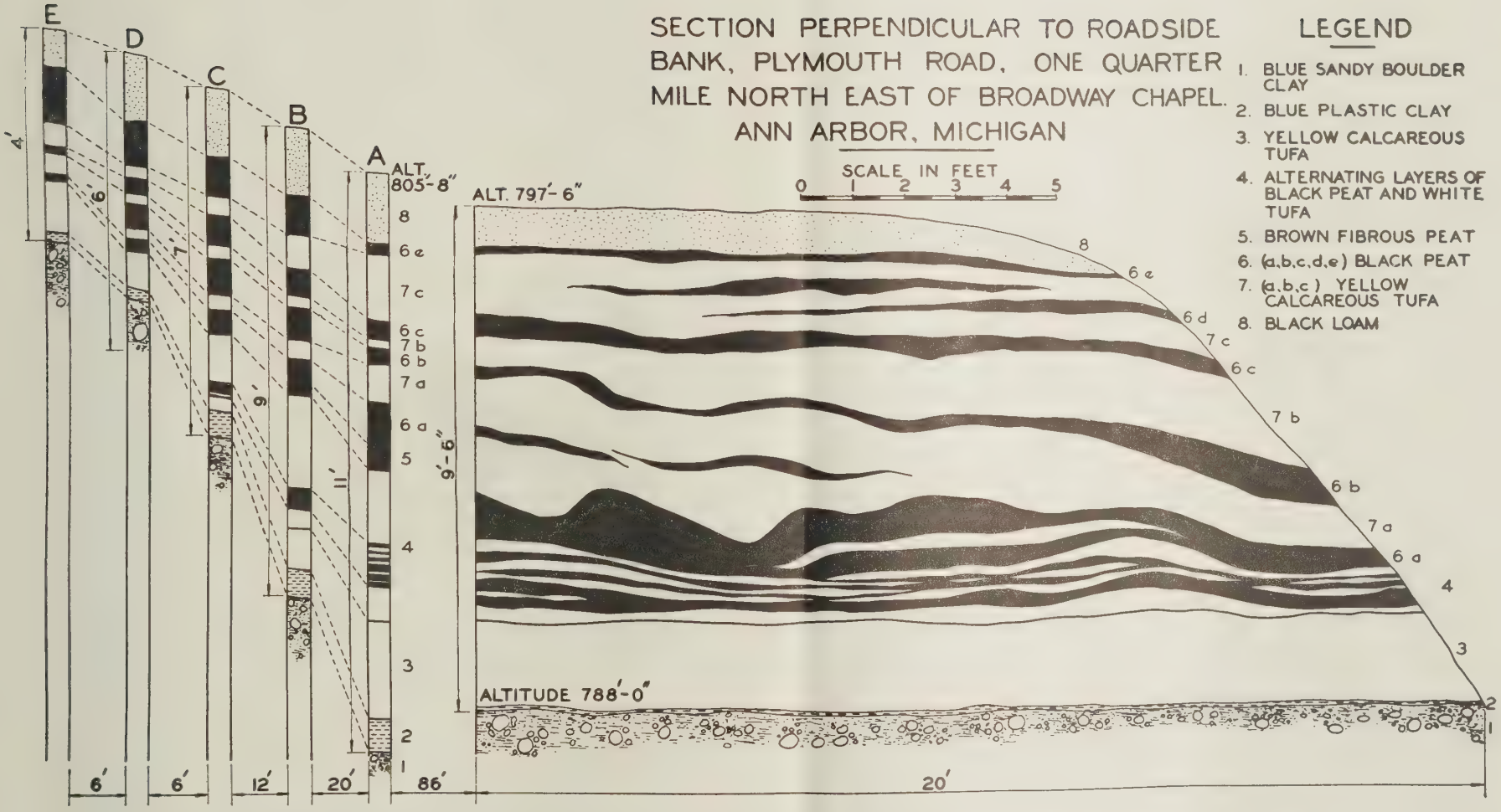


FIG. 3. Diagram showing strata of tufa and peat in Maumee terrace at Ann Arbor, Michigan, as disclosed in trench and postholes A, B, C, D, and E

condition. The snail eggs found in the deposit, together with the shells and a deer antler, were identified to the species. Some of the pollen, most of the seeds, and all the woods were identified to the species. The remainder of the pollen was identified to the genus or (in one group) to the family (Betulaceae). Although this family was treated as a unit in the pollen percentage counts, the component genera received consideration in the discussion.

The amount and kind of fossil evidence often differed for each plant; for example, the water lily was represented by internal trichomes (trichoblasts); Sphagnum, by spores and leaves; the bracken fern, *Pteris aquilina*, by sporangia; the bramble, Rubus, by pollen and seeds; the willow, Salix, by pollen; the tamarack, *Larix laricina*, by pollen and wood, and the white pine, *Pinus Strobus*, by wood (Tables I–II). The ecological significance of the fossils was of paramount importance in this investigation (Cain, 1944).

CLASSIFICATION OF THE PLANT FOSSILS

Thallophyta

fungi

Spores.

Bryophyta

sphagnaceae

Sphagnum sp.

Spores and leaf fragments. Common in bogs.

amblystegiaceae

Amblystegium sp.

Portion of leaf of this moss.

Pteridophyta

polypodiaceae

Pteris aquilina L. (Bracken fern)

Spores and sporangia. This fern is common in thickets and on hillsides; invades burnt-over forests of Michigan.

SPERMATOPHYTA

PINACEAE

Pinus Strobus L. (White pine)

(Plate VI, Fig. 1)

Safely, 1867; Penhallow, 1896, 1899; Hollick, 1906; West, 1948.

Pollen and wood. Formerly dominant as far south as Van Buren County, Michigan; a few relict trees are found at Howell, Michigan, about twenty-five miles north of Ann Arbor.

Pinus Banksiana Lamb. (Northern scrub pine)

Pollen. The characteristic tree of the sand plains in the northern part of the Southern Peninsula; absent from Washtenaw County.

Larix laricina (DuRoi) Koch (Tamarack)

(Plate VI, Fig. 2)

Safely, 1867; Dawson and Penhallow, 1890; Keyes, 1893; MacBride, 1896; Penhallow, 1896, 1899, 1904; Calvin, 1898; Coleman, 1899; Tarr, 1904; Baker, 1920; Cooper and Foot, 1932; Brown, 1938; West, 1948.

Pollen and wood. This tree is abundant in swampy areas and bogs in Michigan.

Picea sp. (Spruce)

Pollen.

Picea canadensis (Mill.) BSP. (White spruce)

Safely, 1867; Baker, 1920; Cooper and Foot, 1932; Wilson, 1932; Hansen, 1935; Brown, 1938.

Seed and wood. A dominant tree of the Picea–Abies association in the northern part of the Northern Peninsula; infrequent in bogs. Extends along the Lake Huron shore from Bay City to Mackinaw City, Michigan.

Picea mariana (Mill.) BSP. (Black spruce)

(Plate VII, Fig. 1)

Safely, 1867; Green, 1870; Bain, 1895; Coleman, 1899; Baker, 1920; Cooper and Foot, 1932; Wilson, 1932.

Pollen and wood. Abundant in tamarack and cedar bogs, and may be found as a rare relict in the vicinity of Ann Arbor.

Abies balsamea (L.) Mill. (Balsam fir)

(Plate VII, Fig. 2)

Coleman, 1895; Baker, 1920.

Pollen and wood. Balsam fir is one of the dominants of the climax forest in Isle Royale. Port Austin in Huron County is its southern limit in Michigan.

Tsuga canadensis (L.) Carr. (Hemlock)

West, 1948.

Pollen. One of the dominants of beech–maple forests in the northern part of the Southern Peninsula of Michigan. Extends as far south as Port Huron on the eastern side.

Thuja occidentalis L. (Arbor vitae)

Dawson and Penhallow, 1890; Baker, 1920; Brown, 1938; West, 1948.

Pollen. Dominant tree in cedar bogs of Michigan. Extends as far south as St. Clair County (Gates and Ehlers, 1924), and to the Waterloo area of Washtenaw and Jackson counties, where it is a rare relict.

TYPHACEAE

Typha sp. (Cattail)

West, 1948.

Pollen. Common in edges of bogs and ditches.

NAJADACEAE

Potamogeton sp. (Pondweed)

Pollen. Three species frequently found in ponds and quiet streams.

CYPERACEAE

Eleocharis sp. (Spike rush)

West, 1948.

Pollen. Four species common in shallow water.

Scirpus sp. (Bulrush)
(Plate VIII, Fig. 1)

Brown, 1938.

Pollen and achene. Four species abundant and sometimes dominant in aquatic associations.

Carex sp.

Dawson and Penhallow, 1890; Penhallow, 1900; Berry, 1924, 1933; Brown, 1938; West, 1948.

Pollen. Fifty species found in different habitats in Washtenaw County.

Carex retrorsa Schwein. (Sedge)
(Plate VIII, Fig. 2)

West, 1948.

Achene. One of the commonest sedges in Michigan.

GRAMINEAE

Pollen.

SALICACEAE

Salix sp. (Willow)

Brown, 1938; West, 1948.

More than one species seems to be present. Seven species common in county.

Populus sp. (Poplar)

Pollen. Three species frequently found in this area.

JUGLANDACEAE

Juglans sp. (Walnut)

Brown, 1938.

Pollen.

Carya sp. (Hickory)

Brown, 1938; West, 1948.

Pollen. Four species common in the oak–hickory forest of southern Michigan.

BETULACEAE

Corylus sp. (Hazelnut)
Betula sp. (Birch)
Alnus sp. (Alder)

Pollen.

FAGACEAE

Fagus sp. (Beech)

Hollick, 1906; Berry, 1907, 1914, 1926, 1933; Emerson, 1917; Baker, 1920; West, 1948.

Pollen. *Fagus grandifolia* is a dominant in the beech–maple forest of the northern two thirds of Michigan; common on rich soil.

Quercus sp. (Oak)

West, 1948.

Pollen. At least six species very common.

Quercus alba L. (White oak)
(Plate IX, Fig. 2)

Penhallow, 1904; Berry, 1907, 1912; Emerson, 1917.

Pollen and wood. Common in oak–hickory forests of Washtenaw County.

URTICACEAE

Ulmus sp. (Elm)

Penhallow, 1896, 1899, 1907; Brown, 1938.

Pollen. Two species found along rivers.

NYMPHAEACEAE

Trichoblasts.

ROSACEAE

Rubus idaeus var. *aculeatissimus*
[C. A. Mey.] Regel & Tiling (?) (Wild red raspberry)
(Plate VIII, Fig. 3)

Berry, 1907, 1914, 1924, 1926, 1933; Brown, 1938; West, 1948.

Seeds. Occurs in the northern part of the Southern Peninsula in burnt-over beech–maple land and in other associations; common in dry soil.

Rubus occidentalis L. (?) (Black raspberry)
(Plate VIII, Fig. 5)

Seeds. Frequent in woods and along fence rows in the vicinity of Ann Arbor.

Rubus allegheniensis Porter (?) (Blackberry)
(Plate VIII, Fig. 4)

West, 1948.

Seed. Dominant in bramble association, especially on sandy soil in the northern part of the Southern Peninsula; infrequent in present flora of Washtenaw County.

Prunus sp.

Brown, 1938.

Pollen. Two species common in county.

RUTACEAE

Zanthoxylum americanum Mill. (Prickly ash)
(Plate VIII, Fig. 9)

West, 1948.

Seed. Found in rocky woods and along river banks in Washtenaw County.

ACERACEAE

Acer sp. (Maple)

Dawson and Penhallow, 1890, Emerson, 1917; West, 1948.

Pollen. More than one species seems to be present. Seven species are found in present flora.

VITACEAE

Vitis vulpina L. (River-bank grape)
(Plate VIII, Fig. 8)

Brown, 1938; West, 1948.

Charred seed. This grape grows along stream banks or near water; infrequent in Washtenaw County.

TILIACEAE

Tilia sp. (Basswood)

Penhallow, 1899, 1907; West, 1948.

Pollen. Common in rich woods.

ONAGRACEAE

Epilobium sp. (Fireweed)

Pollen. Probably *E. angustifolium*, which invades clearings and newly burned ground; frequent.

OLEACEAE

Fraxinus sp. (Ash)

Penhallow, 1899, 1900; Brown, 1938.

Pollen.

Fraxinus nigra Marsh. (Black ash)
(Plate IX, Fig. 1)

Penhallow, 1899; West, 1935, 1948.

Wood, probably pollen. Infrequent in this locality; common in swamps and river bottoms in northern Michigan.

CAPRIFOLIACEAE

Sambucus canadensis L. (Common elder)
(Plate VIII, Fig. 7)

Berry, 1924, 1933; Brown, 1938; West, 1948.

Seeds. Common in rich soil, open places.

Sambucus racemosa L. (Red-berried elder)
(Plate VIII, Fig. 6)

West, 1948.

Seeds. Infrequent in this locality.

COMPOSITAE

Ambrosia sp. (Ragweed)

Pollen.

Erechtites sp. (Fireweed)

Pollen. May represent *E. hieracifolia*, which comes in after burns. Frequent in woods.

MOLLUSCA OF THE DEPOSIT

The tufa and likewise the peat contain a vast number of mollusks which were identified by Mr. Calvin Goodrich, emeritus curator of Mollusca in the Museum of Zoology, University of Michigan.

The mollusks were picked out of the embedding matrix of nineteen samples (Table I) taken from the middle of the trench shown in Figure 3. They afford an interesting record of vertical distribution (Table III).

TABLE III

VERTICAL DISTRIBUTION OF THE FOSSIL AND RECENT MOLLUSCA,* FROM THE BOTTOM (SAMPLE 1) TO THE TOP OF THE DEPOSIT AND INCLUDING THE SURFACE (SAMPLE 19)

Number of sample from deposit (see Table I)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Terrestrial Species																			
Anguispira alternata (Say)	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	+	.	+
solitaria (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Carychium exiguum (Say)	.	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
exile (Lea)	.	.	.	.	.	.	.	.	.	+	.	+	.	.	+	.	.	+	.
Cochlicopa lubrica (Müller)	.	.	+	+	+	.	.	.	.	+	.	+	+	+	+	+	+	.	+
Euconulus chersinus polygyratus (Pilsbry)	+	.	+	+	+	.	+	+	.	+	.	+	+	+	+	+	+	.	+
Gastrocopta armifera (Say)	.	.	+	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	+
contracta (Say)	.	.	+	+	+	+	+	+	.	+	+	+	+	+	+	+	+	+	+
pentodon (Say)	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Gastrodonta ligera (Say)	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	+
Gonodiscus cronkhitei anthonyi (Pilsbry)	+	.	+	.	+	.	+	.	.	+	.	+	+	+	+	+	+	+	+
cronkhitei anthonyi (Pilsbry)? (eggs)	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Hawaiia minusculus (Binney)	.	.	.	.	+	.	.	.	+	.	.	+	.	.	+	+	+	+	.
Helicodiscus parallelus (Say)	.	.	.	.	.	.	.	.	+	+	.	+	+	+	+	.	+	+	+
Polygyra albolabris (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
fraterna (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
fraudulenta (Pilsbry)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+
hirsuta (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
inflecta (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
monodon (Rackett)	+	.	.	.	.	.	.	.	.	+	+	.	+	+	+	+	+	.	+
profunda (Say)	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+
thyroidus (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+
tridentata (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+

* Goodrich, 1932.

Number of sample from deposit (see Table I)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Pupoides marginatus (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Retinella hammonis (Ström)	+	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.
indentata (Say)	+	+	+	.	+	.	+	+	+	+	+	+	+	+	+	+	+	.	.
Striatura exiguum (Stimpson)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
milium (Morse)	+	.	+	+	.	.	.	.	.	+	.	+	+	+	+	+	+	.	.
Strobilops affinis (Pilsbry)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
labyrinthica (Say)	.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	.
labyrinthica virgo (Pilsbry)	.	.	+	+	+	.	.	.	.	+	.	+	+	+	+	.	.	+	.
Succinea avara (Say)	+	.	.	.	.	.	+	+	+	+	+	+	+	+	+	+	.	.	+
ovalis (Say)	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	+	.	+	+
retusa (Lea) amphib.	+	.	+	+	+	+	+	+	+	.	+	.	+	.	.	+	+	+	.
Vallonia pulchella (Müller)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.
Vertigo gouldii (Binney)	.	.	+	+	.	.	.	.	+	+	+	+	.	+	+	.	+	.	.
morsei (Sterki)	.	.	.	+	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.
ovata (Say)	.	.	+	+	+	+	+	+	+	+	+	+	+	+	.	+	+	.	
tridentata (Wolf)	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	+
ventricosa (Morse)	+	+	+	+	+	.	+	+	+	.	.	+	+	+	+	.	+	.	
Vitrea indentata (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Zonitoides arboreus (Say)	.	.	+	.	.	.	+	.	.	.	.	+	+	.	+	.	.	.	+
milium (Morse)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Bog or fresh-water species																			
Gyraulus parvus (Say)	+	.	.	+	+	.	+	+	+	.	+	.	+	+	+	+	+	+	.
Lymnaea dalli (Baker)	.	.	.	.	.	.	.	+	+	+	+	+	+	+	+	.	.	+	.
humilis modicella (Say)	.	.	.	.	+	.	+	.	.	.	.	.	+	+	.	.	.	.	.
obrussa (Say)	+	.	.	.	.	+	+	+	+	.	+	.	.	+	+	.	.	.	.
Physa gyrina (Say)	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.
Pisidium sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.
Pomatiopsis lapidaria (Say)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+

Ninety per cent of the Mollusca of the deposit proved to be terrestrial, and this is true even of the lowest layer. All the species are living, and none shows any significant deviation from the living representatives.

The few fresh-water species (pulmonates, with the exception of the ctenobranchiate *Pomatiopsis lapidaria*) are such as might occur in very shallow water, as at the edge of the deposit in its initial stages or in pools among the hummocks of the irregular surface later on.

The great numbers of specimens of *Carychium* indicate a continuously wet situation, as does *Strobilops* to a lesser degree. A common habitat for *Vertigo* in the Ann Arbor region today is the steep banks of ravines, where seepage permits a thick growth of mosses.

The following land species are typical in peat bogs:

Carychium exiguum (Say)
Carychium exile (Lea)
Helicodiscus parallelus (Say)
Polygyra monodon (Rackett)
Strobilops labyrinthica (Say)
Succinea avara (Say)
Succinea retusa (Lea)
Vertigo spp.
Vitrea hammonis (Ström)
Vitrea indentata (Say)

The Mollusca collected at the very surface make a long list, and all but the following are also found buried in the deposit:

Anguispira solitaria (Say)
Polygyra albolabris (Say)
Polygyra fraterna (Say)
Polygyra inflecta (Say)
Strobilops affinis (Pilsbry)

These species may have existed a hundred years ago, when the forest was cleared. Only one of those on top of the deposit was found alive, namely, *Anguispira alternata* (Say). The surface (i.e. Recent) shells were identified by Dr. Allen Archer and are recorded in Column 19 of Table III.

In addition to the species listed from the trench, the postholes and other places yielded records of the following species, which were not definitely placed in the vertical sequence:

Euconulus fulvus (Müller)
Lymnaea sp., probably *L. palustris* (Müller)
Polygyra hirsuta (Say)
Retinella electrina (Gould)
Valvata tricarinata (Say)
Vitrea indentata (Say)
Zonitoides ligerus (Say)
Zonitoides milium (Morse)

INTERPRETATION OF THE DEPOSIT

Silt sinking from glacial waters to the bottom of the estuary formed an impervious layer of clay. By the opening of a lower outlet farther to the northeast, across the "Thumb" of Michigan, the level of glacial Lake Maumee was lowered and likewise the level of the estuary.

The rainfall of the adjoining upland collected in this part of the gravel catchment basin of the Huron River and flowed from the spring level of this bank and over the impervious Lake Maumee clay as the level of the estuary was lowered.

The plants growing in these spring waters all the way down the slope afforded a suitable substratum for lime-depositing organisms, which covered them with a layer of lime. As the vegetation decayed, cavities were left which gave to the tufa its characteristic porous texture. It was probably in this manner that the calcareous layers of the terrace were formed (Pls. II–III). Even at the present time

tufa is still being formed at the site of the deposit. A small rill of spring water, which flows along the roadside bank, is choked throughout most of its course by dense mats of Chara (probably *C. vulgaris*). The large number of land shells (90 per cent) found in the deposit gave additional evidence that most of it was formed in seepage water of little depth.

Considerable time probably elapsed before about two feet of basal tufa was formed on the glacial lake clay (Fig. 3, Stratum 3). As the climate became drier, the ground water level was lowered, and many of the springs ceased to flow and produce tufa. Conditions thus became favorable for the growth of bog plants which, during an unknown interval of time, built up a layer of peat on the tufa. It is possible that each layer of tufa was formed during periods of increased moisture, which would augment the volume of water flowing from the lime-charged springs, while, on the other hand, each continuous layer of peat may represent a period of decreased moisture, with conditions favorable for the growth of a bog flora (Clements, 1916).

An examination of the lowest tufa (Fig. 3) gave no evidence of the first pioneers on the land surface recently exposed by the melting glacier, but a thin gray lens of peat included within the tufa contained the pollen of alder, birch, willow, hemlock, spruce, and pine. The significance of this group of pioneer trees may be clarified by the reports of scientists who have studied the development of vegetation in Alaska. Raymond Taylor (1932) states that at Glacier Bay, Alaska, "Pure stands of spruce . . . seem to be sub-climax and are characterized . . . by a sterile sandy soil covered by a mull composed of the debris of alder, willow, and poplar." It is altogether possible that these deciduous trees may have played a similar rôle in preparing the soil for the spruce seedlings in this early postglacial forest. By the use of permanent quadrats Cooper (1939) has studied vegetational development at Glacier Bay, Alaska. He found that the pioneer community consisted of mosses, Epilobium, Equisetum, Dryas, and prostrate willows. The next stage was the willow–alder thicket, and the final and climax stage had as dominants the Sitka spruce, *Picea sitchensis*, and two hemlocks, *Tsuga heterophylla* and *T. Mertensiana*. Baxter and Wadsworth (1939), in a study of transects on bars of the lower Yukon River at Koyukuk, Alaska, found that the order of succession was willow, poplar, alder, birch, and spruce. It is likely that willows were the

first trees to advance into this region and that they were followed by alder, birch, spruce, hemlock, and pine (Table IV).

TABLE IV

PROBABLE ORDER OF PLANT SUCCESSION AT ANN ARBOR, MICHIGAN, AFTER RETREAT OF THE WISCONSIN GLACIER (MOST RECENT PLANTS AT TOP)

(Groups arranged systematically)

Corylus, Prunus, *Vitis vulpina*, Ambrosia

↑

Pinus Strobus, Juglans, *Quercus alba, Zanthoxylum americanum, Fraxinus nigra*

|

Fagus, Ulmus, Acer, Tilia, Fraxinus, *Sambucus racemosa*

|

Pteris aquilina, Rubus occidentalis (?), Epilobium, *Sambucus canadensis*, Erechtites

|

FIRE

|

Carya, Quercus

|

Gramineae, *Rubus idaeus* var. *aculeatissimus* (?), *R. allegheniensis* (?)

|

FIRE (?)

|

Sphagnum, *Pinus Banksiana, Larix laricina, Picea canadensis, P. mariana, Abies balsamea, Tsuga canadensis, Thuja occidentalis*, Typha, Eleocharis, Scirpus, *Carex retrorsa*, Nymphaeaceae

|

Picea

|

Betula

|

Alnus

|

Salix

|

⋔

The layer of peat that lies just above the basal tufa (Fig. 3, lower part of layer 4) contained pollen, spores, seeds, wood (Fig. 4), and shells. From the identified fossils it may be inferred that a bog, with its characteristic zones of plant life, occupied the margin of the estuary. There were water lilies floating in the water. Sedges, including *Carex retrorsa*, together with a spikerush, Eleocharis, cattails, Typha, and a bulrush, Scirpus, grew in shallower water behind the lilies. Sphagnum formed tufts among the sedges. Tamarack, *Larix laricina*, and the black spruce, *Picea mariana*, were dominant trees of the bog, which also supported the balsam fir, *Abies balsamea*,

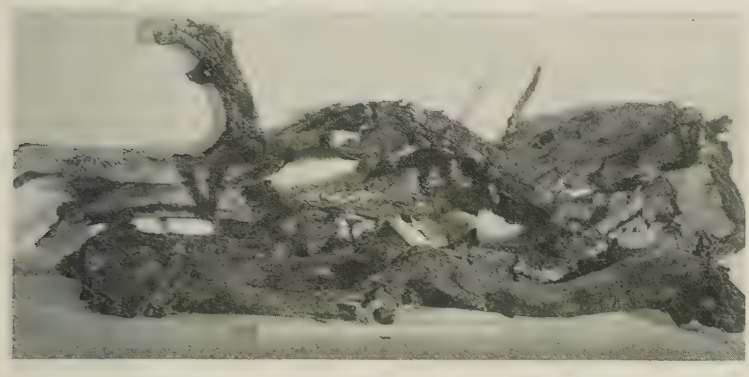


Fig. 4. Coniferous wood from variegated peat layer (Fig. 3, Stratum 4), Maumee deposit. The rule is one foot long

the white spruce, *Picea canadensis*, and arbor vitae, *Thuja occidentalis*. On well-leached gravel or sandy ridges grew the northern scrub pine, *Pinus Banksiana*. There were clumps of hemlock, *Tsuga canadensis*, on lower ground, and along the watercourses were willows and alders. Birds may have dropped near the bog the seeds of the red raspberry, *Rubus idaeus* var. *aculeatissimus* (?), and the blackberry, *R. alleghcniensis* (?) growing on the border of the approaching oak–hickory forest (Figs. 5–6, 95 in.).

Thus in the peat layer upon the basal tufa was preserved evidence not only of the presence of a bog with its characteristic zones of plant life, but also of the northern coniferous forest with its pioneers, and a vanguard of shrubs heralding the approach of the deciduous forest.

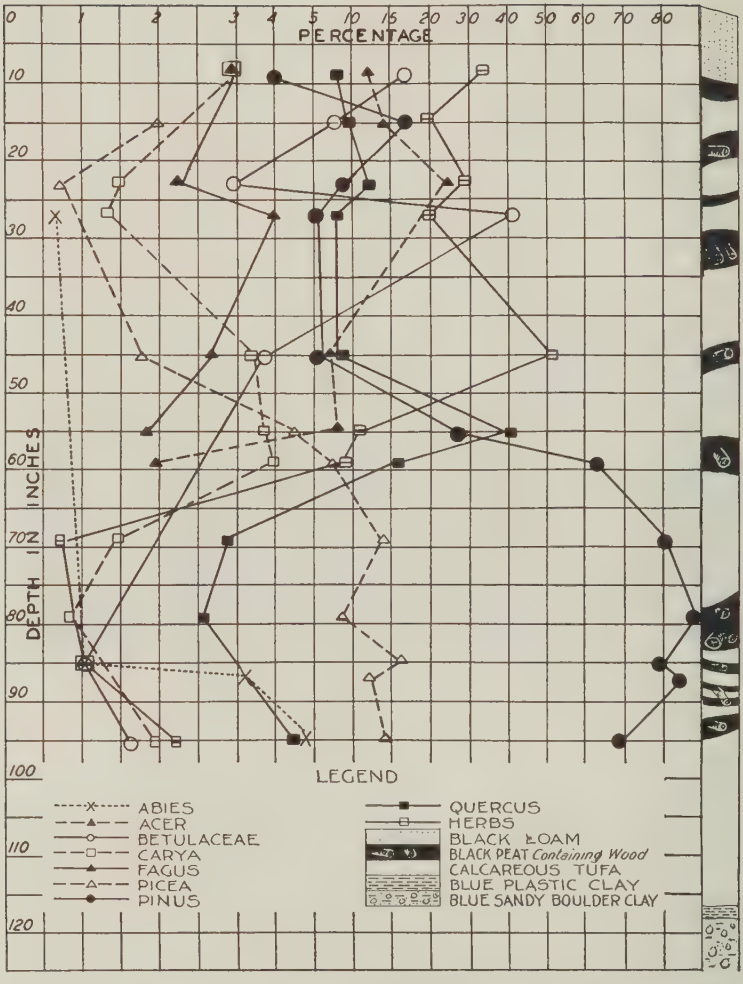


FIG. 5. Pollen diagram of Maumee terrace, indicating the development of vegetation at the site of Ann Arbor, Michigan, after the retreat of the Wisconsin glacier

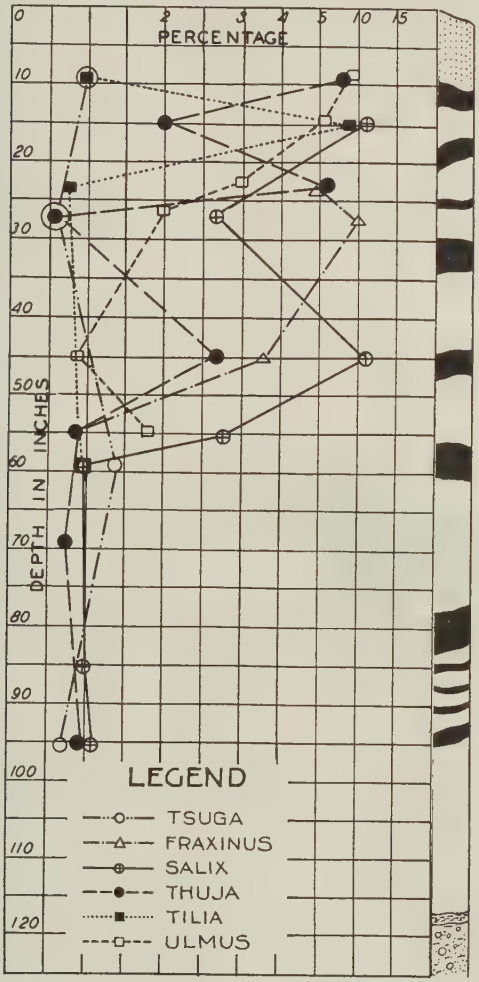


FIG. 6. Pollen diagram of Maumee terrace, indicating the development of vegetation at the site of Ann Arbor, Michigan, after the retreat of the Wisconsin glacier

The ice front, which had receded to a line east of Ypsilanti, was over twelve miles distant when the northern conifers entered and later reached their maximum development at Ann Arbor. It is probable, therefore, that zones of both tundra and scrub separated the northern coniferous forest from the margin of the ice sheet.

The proximity of the Wisconsin glacier during the period of shrinkage and waste would not require one to believe that southern Michigan had a boreal climate when the northern conifers occupied the region; on the contrary, it is likely that the climate was no more rigorous than that of northern Michigan today.

After the maximum development was attained by the coniferous forest (Fig. 5, 95 in.) the pines alone began a gradual increase until they became by far the most abundant trees in the area. There was a similar decrease in the deciduous trees which had entered the region. The increase in pines is believed to have taken place during a long dry period of peat formation. Although charred plant material was not found in this layer of peat, fires may have occurred in the surrounding region. They probably destroyed the seedlings of the invading oaks and other hardwoods, and may have provided conditions favorable for dominance of the fire-tolerant pines. Studies on the effect of fire on longleaf and slash pines in South Carolina and Louisiana by Frank Heyward (1939) show that thousands of acres of longleaf pine owe their dominance to tolerance of fire which destroyed seedlings of the invading hardwoods. A few pollen grains of grasses, Gramineae, were present here and also in the top stratum of the deposit.

After the pines had reached a maximum (Fig. 5, 79 in.) there occurred a gradual change in the facies of the formation. The deciduous trees, competing successfully with the conifers, increased at their expense. Finally, the oaks became dominant (Fig. 5, 55 in.), with pines ranking next in abundance. Hickory, although increasing in percentage, still lagged behind the dominant oak. Besides a few elms along the river there were maples and beeches growing in well-drained rich soil in the forest.

Forest fires are known to have occurred in the Pleistocene, and there is evidence of them in this area in the form of charcoal fragments and a charred seed found in the deposit. Coleman (1895) wrote: "It appears that forest fires raged in Ontario then as now,

for fragments of charcoal or chips charred on one edge are not infrequently found mixed with quite uncarbonized woody material."

While the oaks were dominant, a fire swept the country, as is indicated by charcoal found 55 inches below the surface. Whether the fire was local or general in extent cannot be ascertained. However, charcoal fragments were present from a depth of 55 inches all the way to the top of the deposit, which indicates not one but probably several fires. The low pollen count, from 55 to 27 inches (Figs. 5–6), and also the total absence of Sphagnum leaves and in their place black structureless microscopic remains seem to indicate that the fire was general in extent. It damaged not only the bog, but also much of the vegetation of the surrounding region; only a few trees were left to reseed the soil.

After the fire a burn subsere consisting of the usual stages of annual and perennial herbs, shrubs, and trees was inaugurated in the area now freed of competition by the subclimax species (Clements, 1920). Fungi were abundant in the bog after the fire. This inference is based not only on the large percentage of spores present but also on observations made after a severe fire which occurred in 1931 in Mud Lake bog about twelve miles from Ann Arbor. Quantities of fungi, some of them undescribed species, appeared in this bog soon after the burn. The numerous fungi, including rusts, which continued to occur in the spore counts during this period (Fig. 5, 55–27 in.), may indicate the presence of rusts on the fireweeds, willows, and poplars, which are sometimes heavily infected with them.

The fire indicator, bracken fern, *Pteris aquilina*, probably formed extensive societies over the burn-scarred region. Among the plants which quickly invaded after the burn and became widespread because of their easily disseminated seeds were the fireweeds, Epilobium and Erechtites. Sometime later *Rubus idaeus* var. *aculeatissimus* (?) and *R. allegheniensis* (?) became abundant. The former is now dominant in burnt-over beech–maple land in the northern part of the Southern Peninsula of Michigan.

The presence of alder, hazel, and birch in large numbers may account for the marked increase in the pollen of Betulaceae after the fire. It may be surmised that the fire indicators, paper birch, *Betula alba* var. *papyrifera*, and the American aspen, *Populus tremuloides*, came in after the burn, although no fossil evidence of these species was found.

Meanwhile, in this region now characterized by fire indicators the pollen counts suggest that the oaks and the conifers at first decreased and then remained stationary while the elm, beech, ash, maple, and birches increased in varying amounts. It is likely that during this period there were many ground fires that prolonged favorable conditions not only for the fire indicators, but also for the continuance of an oak–hickory subclimax (Weaver and Clements, 1929). The lessening amount of hickory and beech that is indicated by pollen throughout the period may have resulted from ground fires. Moreover, general observations both in Michigan and elsewhere have shown that these trees suffer severely from light ground fires that readily scar the base of the trees and leave them open to attack by fungi.

Finally, after a steady gain, maple, oak, and elm probably became dominants in their respective habitats (Figs. 5-6, 27 in.). The walnut, Juglans, was a recent invader in the woods. The oaks and hickories occupied dry hills and lighter soils. In still drier upland situations the white pine, *Pinus Strobus*, doubtless formed pure stands, and the scrub pine occupied well-leached sandy hills. Arbor vitae and hemlock were also present, and in the shrub layer grew the common elder, *Sambucus canadensis*, the red-berried elder, *S. racemosa*, and the black raspberry, *Rubus occidentalis*. The Virginia white-tailed deer, *Odocoileus virginianus* (Fig. 7), roamed through the woods.

There is some evidence that shortly after the maples and oaks became abundant in the forest (Fig. 5, 23 in.) another fire occurred, which, although not so severe as an earlier one, was more severe than the ground fires that swept through the locality at frequent intervals. Beech, together with members of the Betulaceae, appear to have been badly injured. This family decreased very suddenly but after the fire regained dominance. In the herbaceous layer were fireweeds and the ragweed Ambrosia.

It is likely that, instead of the normal succession of herbs, shrubs, and trees developing in this burn subsere as in the former one, there was formed an intricate pattern of dominants. Because of the root-sprouting habit of certain shrubs, as well as of birch and aspen, and because of the release of seeds from the cones of scrub pine and white pine, these were all able to begin development the first year about the time the herbs began to appear. Thus the

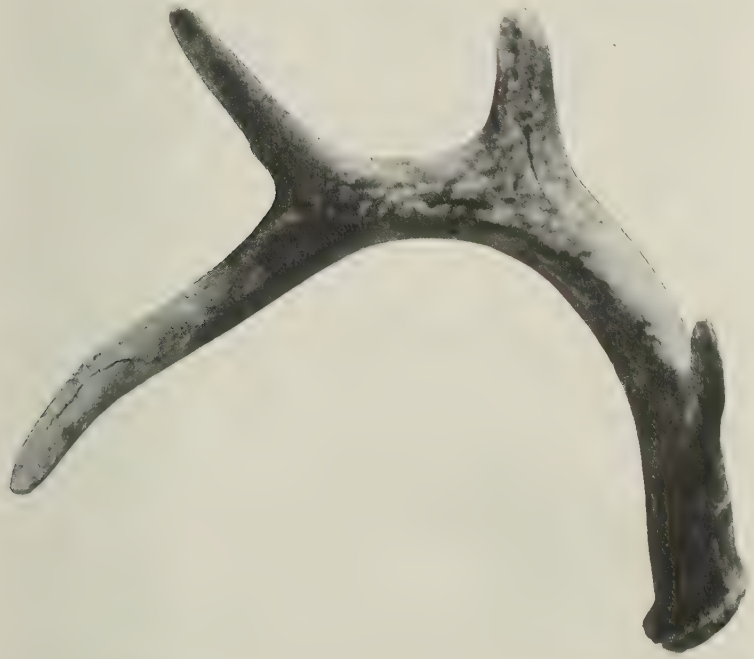


FIG. 7. Normally shed antler of Virginia white-tailed deer, *Odocoileus virginianus*, from Stratum 6d (see Fig. 3)

dominants of the herbs, shrubs, and trees probably appeared at almost the same time, but each dropped out in turn as competition with the next higher member became too great (Clements, 1920).

The final record of fossil vegetation from the Maumee terrace may be used to establish the plant communities in their natural habitats. In the drier uplands the forests were largely dominated by the oak hickory association (including *Quercus alba*) with the undershrub Corylus, while on the heavy clay soils were representatives of the beech maple climax forest. On the flood plains of the Huron River there occurred such trees as Ulmus, Tilia, *Fraxinus nigra*, Juglans, *Zanthoxylum americanum*, and Prunus. Along the river shores were growing thickets of willow, poplar, and alder, among which twined *Vitis vulpina*. There were brambles of black-

berries and red raspberries, and in open places dense stands of the common elder. In the herbaceous layer were composites, grasses, ferns, and mosses. The mosses were represented only by spores and a portion of a tiny leaf of *Amblystegium sp.* The reduced number of pollen grains and woods of coniferous origin seems to indicate that, except for hemlock and a few other relicts, the conifers had followed the zones of scrub and tundra as they migrated northward in the wake of the retreating ice.

The movement of climax zones northward is indicated by relict boreal species which still persist in this region "several hundred miles behind the zone to which they belong" (Clements, 1916). White pines may be found twenty-five miles north at Howell, Michigan. In the tamarack bogs of Washtenaw County *Larix laricina* is dominant in the bog-tree stage, with *Picea mariana* sometimes present. There are also a few cedar bogs in Washtenaw and Jackson counties in which *Thuja occidentalis* is a rare tree. These relicts now grow in bogs where they find protection and compensation against the new climate (Clements, 1934).

SUMMARY AND CONCLUSIONS

The alternating strata of tufa and peat in the Maumee terrace at Ann Arbor have recorded the successive waves of plant life as they moved northward in the wake of the Wisconsin glacier. They have preserved evidence of a gradual development of the vegetation from the early invaders, which were able to withstand extreme physical conditions, to the final mixed deciduous forest, which required favorable conditions.

Along with the progressive development of the vegetation there was doubtless a corresponding development of the soil, from the sterile till or gravel left by the glacier to the well-drained fertile soil capable of supporting a mixed deciduous forest (Shantz and Zon, 1924). Moreover, along with the development of the vegetation and soil there was a gradual amelioration of the climate which had its resultant effect upon plants and their habitats.

Alternating moist and dry periods were probably indirectly responsible for the production of the layers of tufa and peat respectively. The thick layer of peat (Fig. 3, Stratum 6a) may have been formed during a major dry cycle.

Although the development of the vegetation was inhibited by

fires, after which burn subseres were inaugurated, the course of the succession was resumed each time and finally resulted in a mixed deciduous forest.

1. The tufa–peat deposit at Ann Arbor, Michigan, was formed after the lowering of the level of the highest stage of glacial Lake Maumee.

2. According to the estimate of Dr. Frank Leverett, the oldest part of the deposit was formed about 30,000 years ago.

3. Fifty-five animals, mostly mollusks, and forty-four plants were identified from the deposit.

4. The same species of animals and plants which lived during the closing part of the Wisconsin glacier are present in some part of the state today.

5. The abundance of terrestrial shells and the layers of tufa indicate that much of the deposit was formed in seepage water.

6. The peat and tufa layers may be indirectly related to the amount of precipitation.

7. Willow, alder, birch, and spruce were probably the first trees in the region and may have entered in the order given. They were followed by the northern conifers.

8. The thickest peat layer may indicate a major dry cycle, during which fire-tolerant pines maintained dominance over the deciduous trees.

9. After deciduous trees gained dominance burn subseres were inaugurated by fires.

10. The final record gives a mixed deciduous forest with relicts of the northern coniferous forest.

11. Because of the shrinkage and final disappearance of the ice sheet, the climate appears to have changed from one as cold as that of northern Michigan to one similar to that of central Michigan today.

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EXPLANATION OF PLATE I

Tufa and peat in Maumee terrace bench exposed along the Plymouth Road, in freshly graded highway U.S.–12 (photograph by Professor H. H. Bartlett, 1925)

EXPLANATION OF PLATE II

Three views of the beveled roadside, showing the deposit of tufa interbedded with peat. The cut is roughly parallel to the irregular margin of the Maumee terrace. No regular bedding could be made out until a trench was cut at a right angle to the roadside (photographs by Professor H. H. Bartlett, 1925)

EXPLANATION OF PLATE III

Vertical end wall of the beginning of the trench, showing the following strata:

FIG. 1. Maumee blue plastic clay upon sandy boulder clay

FIG. 2. Yellow tufa

FIG. 3. Variegated peat (peat and tufa); wood at A, B, and C

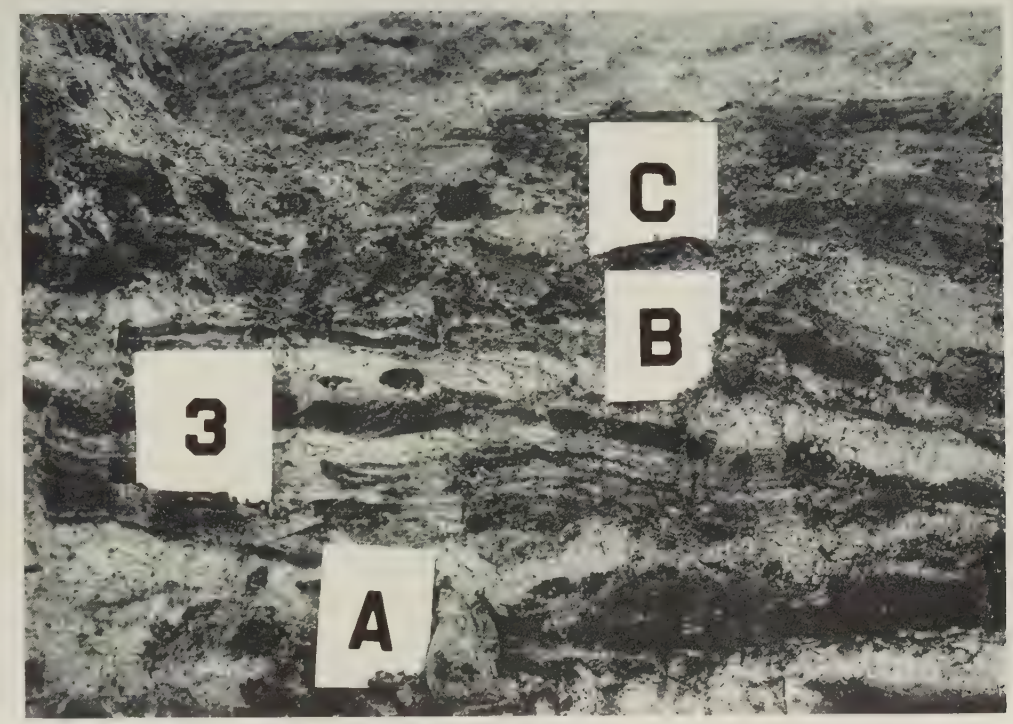
FIGS. 4–10. Tufa and peat in alternating layers

FIG. 11. Topsoil

11
10
9
8
7
6
5
4
C
B
3
A
2
1

EXPLANATION OF PLATE IV

Enlargement of Stratum 3 of Plate III, showing fine stratification. Wood located at A, B, and C


C
B
3
A

EXPLANATION OF PLATE V

FIG. 1. Dr. Frank Leverett, the most distinguished American glacial geologist, determining the altitude of the Maumee deposit

FIG. 2. Trench extending into Maumee terrace from Plymouth Road. Dr. Leverett examining fossils

1

2

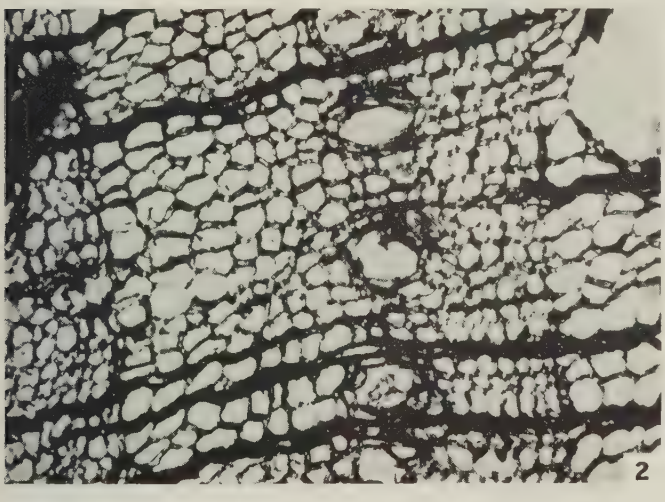
EXPLANATION OF PLATE VI

Transverse sections of woods from the Maumee deposit. Their location is shown in Table II

FIG. 1. *Pinus Strobus* L. × 150

FIG. 2. *Larix laricina* (DuRoi) Koch. × 150

1

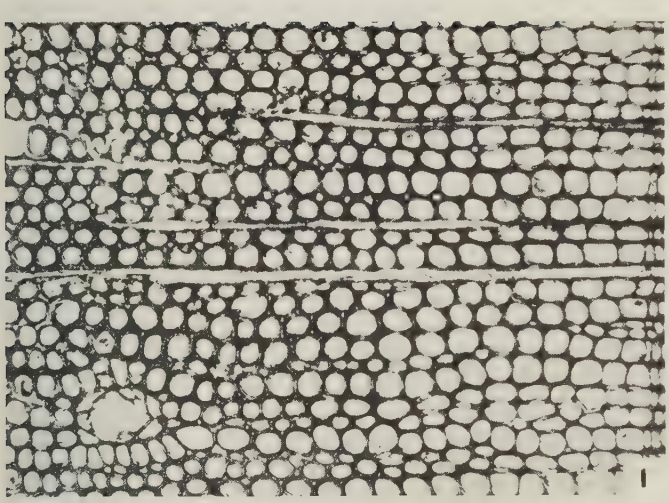

2

EXPLANATION OF PLATE VII

Transverse sections of woods from the Maumee deposit. They were located in Stratum 3, Figure 3, and in other places (Table II)

FIG. 1. *Picea mariana* (Mill.) BSP. × 150

FIG. 2. *Abies balsamea* (L.) Mill. × 150


1

2

EXPLANATION OF PLATE VIII

Seeds and achenes from Maumee deposit. Their location is shown in Table II.

FIG. 1. *Scirpus sp.* Achene. × 6

FIG. 2. *Carex retrorsa* Schwein. Achene. × 4

FIG. 3. *Rubus idaeus* var. *aculeatissimus* [C. A. Mey.] Regel & Tiling (?). Seed × 6

FIG. 4. *Rubus allegheniensis* Porter (?). Seed. × 6

FIG. 5. *Rubus occidentalis* L. (?) Seed. × 6

FIG. 6. *Sambucus racemosa* L. Seed. × 4

FIG. 7. *Sambucus canadensis* L. Seed. × 4

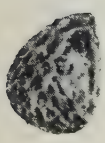
FIG. 8. *Vitis vulpina* L. Seed. × 4

FIG. 9. *Zanthoxylum americanum* Mill. Seed. × 6

1

2

3



4

5

6

7

8

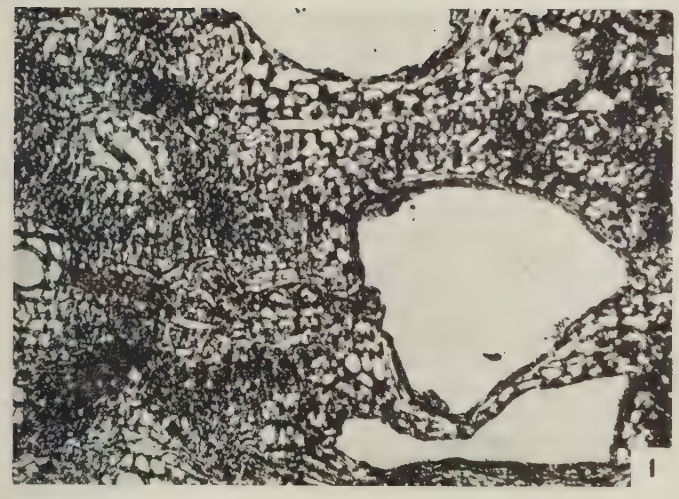
9

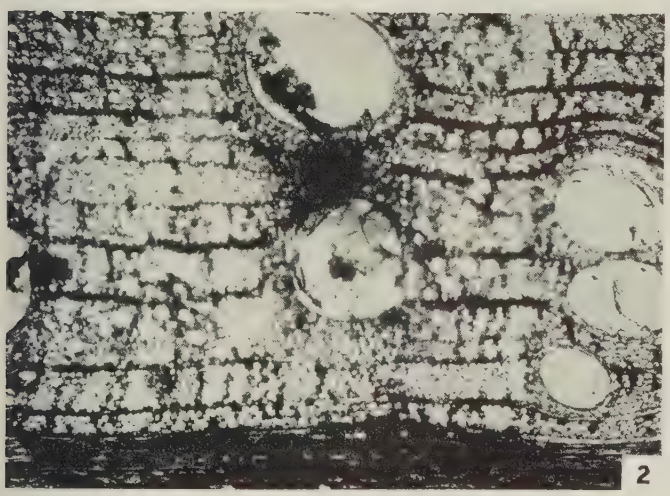
EXPLANATION OF PLATE IX

Transverse sections of woods from the Maumee deposit. Their location is shown in Table II.

FIG. 1. *Fraxinus nigra* Marsh. × 150

FIG. 2. *Quercus alba* L. × 80


1


2

SOME LICHENS FROM IDAHO

JOYCE HEDRICK

THE material upon which this report is based was collected in Idaho by Dr. Alexander H. Smith, botanist in the Herbarium of the University of Michigan, during the summers of 1935, 1939, and 1941. The collecting of lichens was incidental, and time was given to it only when it was not possible to secure other fungi.

Specimens were collected in the southwestern part of the state. In 1935 some were obtained from a petrified forest, south of Caldwell, and just across the state line from the town of Rockville, Oregon. In 1939 a few were found along Thorn Creek, near Boise. In 1939 and 1941 the collections were made in the region about Payette Lakes in the northwestern part of Valley County. Much material was taken from the rocks near Payette Lakes, on the trail to Boulder Lake, at an elevation of about 5,600–5,900 feet, around Louis Lake at 8,000 feet, and as far south as McCall. In 1941 specimens were also collected from the volcanic rocks near Craters of the Moon, at an altitude of about 5,000 feet.

So far as the writer has been able to ascertain, little work on lichens has been done within the State of Idaho. Many small collections have been made from time to time, and these have been reported in various publications, but the writer has seen no comprehensive study of lichens of the state. A number of species from Idaho are given in Fink's *Lichen Flora of the United States* (2). E. C. Berry (1) lists six species of the genus Parmelia from collections in the state, and Albert W. C. Herre (5) adds another species of the same genus in a recent paper.

Owing to the high altitudes and the time of collecting, numerous specimens were found to be immature. Much valuable information might be obtained if specimens could be taken from the same regions later in the summer or very early in the spring.

During the work for this study 276 specimens were identified. These are to be found in the Herbarium of the University of Michigan.

There are 51 species and 2 varieties in 16 genera, which represent 12 families. One variety, *Gyrophora decussata* var. *Darrowii* Frey, which was described from specimens collected in Nevada and California, appears to be frequent in the part of Idaho represented in this article.

List of Species

Dermatocarpon aquaticum (Weis.) Zahlbr. — On rocks in cracks, Boulder Lake Trail, near McCall, 15723, July 27, 1941.

Urceolaria scruposa (Schreb.) Ach. — On rocks, Payette Lakes, 16124, August 7, 1941.

Peltigera canina (L.) Willd. — On soil, Boulder Lake Trail, near McCall, 15716, July 27, 1941.

Lecidea atrobrunnea (Ram.) Schaer. — On petrified wood, across the state line from Rockville, Oregon, 1812, August 27, 1935; on rocks, Payette Lakes, 15676, 15692, 15695, 16102, August 10, 1939; 15677, 15701, 15702, July 20, 1941; 16086, 16088, 16092, 16094, 16096, 16097, 16100, 16101, 16108, 16110, 16112, 16113, 16118, 16120, 16129, 16153, August 7, 1941; Craters of the Moon, 15612, 15624, 15630, July 11, 1941; Louis Lake, near McCall, 15761, 15762, 15765, 15766, 15770, 15773, 15776, 15786, July 27, 1941.

Lecidea auriculata T. Fries. — On rocks, Payette Lakes, 16102, August 10, 1939; Louis Lake, near McCall, 15791, July 27, 1941.

Lecidea fuscescens Sommerf. — On bark of trees, Payette Lakes, 16167, August 6, 1941.

Lecidea lapicida Ach. — On rocks, Louis Lake, near McCall, 15782, July 27, 1941; Payette Lakes, 16128, August 7, 1941.

Lecidea platycarpa Ach. — On petrified wood, across the state line from Rockville, Oregon, 1810, 1814, 1825, August 27, 1935; on rocks, Payette Lakes, 15688, 15689, July 20, 1941; Boulder Lake Trail, near McCall, 15735, 15736, 15737, July 27, 1941; Louis Lake, near McCall, 15769, 15774, July 27, 1941.

Psora globifera Ach. — On soil in cracks between rocks, along Thorn Creek, near Boise, 1824, summer of 1939; Payette Lakes, 15673, 15675, July 20, 1941; 16085, August 7, 1941.

Rhizocarpon geographicum (L.) Lam. & DC. — On rocks, Payette Lakes, 15682, 15691, 16102, 16114, 16126, August 8–10, 1939; 15677, July 20, 1941; 16092, 16100, August 7, 1941; Louis Lake,

near McCall, 15761, 15762, 15764, 15765, 15766, 15770, 15784, 15791, July 27, 1941.

Rhizocarpon grande (Floerke) Arn. — On rocks, Payette Lakes, 16089, 16103, 16151, August 9–10, 1939; 15681, 15683, 15685, 15694, July 20, 1941; 16091, 16107, 16109, 16111, 16121, 16122, 16144, August 7, 1941; Craters of the Moon, 15620, 15629, July 11, 1941; Louis Lake, near McCall, 15790, July 27, 1941.

Cladonia pyxidata (L.) Hoffm. — On soil, Boulder Lake Trail, near McCall, 15729, July 27, 1941; Payette Lakes, 16060, 16061, 16134, August 6–7, 1941.

Gyrophora decussata (Vill.) Zahlbr. — On rocks, Payette Lakes, 16151, August 9, 1939; Craters of the Moon, 15622, July 11, 1941.

Gyrophora decussata var. Darrowii Frey. — On rocks, Payette Lakes, 15679, 15699, August 9–10, 1939; Craters of the Moon, 15608, 15609, 15614, 15618, 15619, 15626, 15629, 15633, 15635, 15636, 15650, 15657, July 11, 1941.

Gyrophora erosa (Weberi) Ach. — On rocks, Boulder Lake Trail, near McCall, 15724, 15732, July 27, 1941.

Gyrophora hyperborea Ach. — On rocks, Payette Lakes, 15705, 15706, 15709, July 20, 1941; 16152, August 7, 1941; Boulder Lake Trail, near McCall, 15724a, July 27, 1941; East Fork of Lake Fork, 15668, July 18, 1941; Craters of the Moon, 15600, 15617, July 11, 1941.

Gyrophora Mühlenbergii Ach. — On rocks, Payette Lakes, 15707, July 20, 1941.

Gyrophora phaea (Tuck.) Nyl. — On rocks, Payette Lakes, 16103, August 10, 1939; 15694a, July 20, 1941; 16136, August 7, 1941.

Gyrophora proboscidea (L.) Ach. — On rocks, Payette Lakes, 15711, 16095, 16098, 16115, 16130, 16146, 16152, 16154, 16155, August 8, 1939.

Gyrophora rugifera (Nyl.) T. Fries. — On rocks, Craters of the Moon, 15623, July 11, 1941.

Gyrophora torrefacta (Leightf.) Cromb. — On rocks, Craters of the Moon, 15638, July 11, 1941.

Gyrophora vellea (L.) Ach. — On rocks, along Thorn Creek, near Boise, 1822, summer of 1939; Payette Lakes, 15674, July 20, 1941; 16131, 16132, 16133, August 7, 1941.

Lecanora alpina Sommerf. — On rocks, Louis Lake, near McCall, 15784, July 27, 1941.

Lecanora atra (Huds.) Ach. — On rocks, Payette Lakes, 16126, August 8, 1939.

Lecanora cinereorufescens (Ach.) Nyl. — On rocks, Payette Lakes, 15692, August 10, 1939.

Lecanora melanophthalma (Lam. & DC) Ramond. — On petrified wood, across the state line from Rockville, Oregon, 1806, 1807, 1811, 1816, August 27, 1935; on rocks, Craters of the Moon, 15614, 15619, 15627, 15629, 15633, 15636, 15643, 15648, 15654, 15656, July 11, 1941.

Lecanora muralis (Schreb.) Rabh. — On petrified wood, across the state line from Rockville, Oregon, 1801, 1808, August 27, 1935.

Lecanora oregana Tuck. — On rocks, Payette Lakes, 16095, 16098, 16125, August 9, 1939; 16084, 16087, August 7, 1941; Craters of the Moon, 15615, 15635, July 11, 1941.

Lecanora polytropa (Ehrh.) Rabh. — On rocks, Payette Lakes, 16116, August 10, 1939.

Lecanora rubina (Vill.) Ach. — On petrified wood, across the state line from Rockville, Oregon, 1813, 1816, 1818, August 27, 1935; on rocks, Craters of the Moon, 15641a, 15655a, 15658, July 11, 1941; Payette Lakes, 16081, August 7, 1941.

Lecanora rupicola (L.) Zahlbr. — On rocks, Payette Lakes, 15682, 15690, August 10, 1939.

Lecanora subfusca (L.) Ach. — On rocks, Payette Lakes, 15678, 16124, August 10, 1939; 15680, 15687, 15700, July 20, 1941; Boulder Lake Trail, near McCall, 15734, July 27, 1941; Louis Lake, near McCall, 15762, 15770, 15770a, 15780, 15783, 15788, 15792, July 27, 1941.

Lecanora subfusca var. coilocarpa Ach. — On bark of trees, Boulder Lake Trail, near McCall, 15726, July 27, 1941; Payette Lakes, 16067a, 16071, 16079, August 6–7, 1941.

Parmelia conspersa (Ehrh.) Ach. — On pebbles, across the state line from Rockville, Oregon, 1820, August 27, 1935.

Parmelia molliuscula Ach. — On soil, across the state line from Rockville, Oregon, 1815, August 27, 1935.

Parmelia olivacea (L.) Ach. — On trees, Payette Lakes, 16137, August 7, 1941.

Parmelia physodes (L.) Ach. — On trees, Payette Lakes, 16068, 16070, 16072, 16074, 16076, 16076a, 16078, 16140, August 7, 1941.

Parmelia sorediata (Ach.) Rohling. — On rocks, Payette Lakes, 15686, July 20, 1941.

Parmelia stygia (L.) Ach. — On rocks, Payette Lakes, 15704, August 8, 1939.

Cetraria californica Tuck. — On trees, Payette Lakes, 16072, 16135, 16139, 16140, August 7, 1941.

Cetraria juniperina (L.) Ach. — On branches of trees, along Thorn Creek, near Boise, 1821, summer of 1939.

Cetraria platyphylla Tuck. — On trees, Payette Lakes, 16072, 16074, 16076, 16076a, 16080, August 7, 1941.

Cetraria tristis (Web.) E. Fries. — On rocks, Payette Lakes, 16151, 16154, 16155, 15684, 15693, 15712, August 9, 1939.

Evernia vulpina (L.) Ach. — On rocks, Payette Lakes, 16082, August 8, 1939; on branches of trees, Payette Lakes, 16072, 16073, 16074, 16076, 16076a, 16076b, 16135, 16140, August 7, 1941; South Fork of Lake Fork, 15667, 15710, July 19–20, 1941; Louis Lake, near McCall, 15763, July 27, 1941.

Alectoria jubata (L.) Ach. — On trees, Payette Lakes, 16066, 16074, 16075, 16076, 16076a, 16076b, 16077, August 7, 1941.

Alectoria oregana Nyl. — On trees, Payette Lakes, 16072, 16074, 16075a, 16076, 16076a, 16135, 16139, 16140, August 7, 1941.

Caloplaca aurantiaca (Leightf.) T. Fries. — On trees, Payette Lakes, 15708, July 20, 1941; 16057, 16059, 16062, August 6, 1941.

Caloplaca elegans (Link.) T. Fries. — On petrified wood, across the state line from Rockville, Oregon, 1800, 1823, 1826, August 27, 1935; on rocks, Payette Lakes, 15698, 15703, 16125, August 8, 1939; Craters of the Moon, 15636, 15637, 15642, 15655, 15660, July 11, 1941.

Caloplaca ferruginea (Huds.) T. Fries. — On rocks, Payette Lakes, 16056, August 9, 1939; 16092, August 7, 1941.

Caloplaca murorum (Hoffm.) T. Fries. — On petrified wood, across the state line from Rockville, Oregon, 1829, August 27, 1935.

Buellia parasema (Ach.) De Not. — On old wood, Payette Lakes, 16058, August 6, 1941.

Physcia pulverulenta (Schreb.) Nyl. — On soil, Payette Lakes, 16142, August 10, 1939; 16138, August 7, 1941.

Physcia setosa (Ach.) Nyl. — On soil over rocks, Boulder Lake Trail, near McCall, 15730, July 27, 1941.

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SOME STUDIES IN THE GENUS HELVELLA *

BESSIE B. KANOUSE

IN CONNECTION with research on the genus Helvella, I have accumulated some data that have a bearing on the taxonomic status of the genus and of some of the species which comprise it. The results are presented in this paper.

Even though the family Helvellaceae is an old one and supposedly well studied, considerable difficulty is still encountered in making identifications in this group. Many genera and subgenera have been proposed, and more than 170 specific and varietal names have been published for the genus Helvella alone. The synonymy for certain species is considerable. In the old literature, particularly, the descriptions were based upon inadequate observations, and emphasis was frequently placed on the macroscopic characters. These become important and reliable when they can be correlated with morphological characters of diagnostic significance, such as structure and spore size. In this genus, especially, the macroscopic characters must be considered carefully and the differences evaluated with caution, since the amount of variation in size, color, and shape of fruit bodies is often great within a species. The illustrations accompanying the older reports tend to emphasize these variations, and undue significance has been attached to them. In the more recent literature there appear to be misinterpretations, so that the present-day taxonomy of the genus, together with the nomenclatorial aspects, is a real problem.

The present study was undertaken primarily to ascertain the usefulness of a chemical test in making identifications of fungi in the Helvellaceae. Smith and Singer (31), in connection with their studies on the genus Cystoderma, found that a 2.5 per cent solution of KOH produced color reactions in the cells of the cuticle ranging through negative (hyaline), olivaceous or strongly olivaceous, to cinnamon-russet. They were able to separate groups of species by means of these reactions, and they place considerable weight upon the results of this technique in species of Cystoderma.

* Papers from the Herbarium of the University of Michigan.

The use of iodine solution as a stain in connection with Discomycetes is standard practice. Rehm (28) employed it regularly. Seaver (30), however, made no reference to it and apparently considered it to be of no value. Lagarde (22) reported upon the use of stains in connection with his studies of several species of Helvella, but KOH was not among those used by him, and he drew no taxonomic conclusions from the stains he did use. In the study of lichens the use of stains is becoming more generally accepted. Nannfeldt (24) suggested the desirability of finding some new chemical test that would aid in identifying Discomycetes.

The observations reported in this paper were made on freehand sections of both fresh and dry herbarium material mounted in 2.5 per cent solution of KOH. The following species were examined: *Helvella albella* (Quél.) Boud. (1 coll.); *H. albip*es Fuck. (2 coll.); *H. atra* Fr. (13 coll.); *H. californica* Phill. (13 coll.); *H. caroliniana* Bosc. ex Fr. (7 coll.); *H. crispa* Fr. (17 coll.); *H. elastica* Bull. ex Fr. (43 coll.); *H. esculenta* Pers. ex Fr. (16 coll.); *H. gigas* Krombh. (5 coll.); *H. infula* Schaeff. ex Fr. (42 coll.); *H. lacunosa* Afz. ex Fr. (53 coll.); *H. monachella* Scop. ex Fr. (1 coll., Rehm: Ascomyceten no. 1561); *H. pezizoides* Afz. ex Fr. (1 coll., Rehm: Ascomyceten no. 1352); *H. pezizoides* var. *minor* (2 coll.); *H. pulla* Holmsk. ex Fr. (1 coll., Rehm: Ascomyceten no. 1251); and *H. sphaerospora* Pk. (4 coll.).

Before taking up the effects of the KOH solution, it is desirable to consider the structure of the fruiting head and to discuss briefly the nature of the hymenial and subhymenial layers. The reader is referred to Corner (10) and to McCubbin (23), who have published upon the morphology of the ascocarps in certain species of the genus Helvella. I have examined more species of Helvella than did these authors, and my observations confirm their findings and extend the knowledge by the study of additional species.

The tissue of the fruiting head is composed of three layers: the hymenium, the hypothecium or medulla, and the exciple or cortex. The hymenium consists of the asci and the paraphyses. The asci are operculate, and the spores fall into several distinct groups: narrowly oblong, containing two oil drops; ellipsoid, containing two oil drops; ellipsoid, with one large oil drop; large ellipsoid, smooth, with one oil drop; large, ellipsoid, rough, with one oil drop; and spherical smooth. The paraphyses exhibit no outstanding difference

in the several species. They vary somewhat, but in general are filiform, clavate-tipped, and branched, frequently at a point below the middle. Septa are commonly present. Coloring matter may give the paraphyses a slight yellowish cast, and in two species, *H. atra* and *H. lacunosa* (which have dark-colored pilei), they are brown. The paraphyses are abundant in all species. They reach the tips of the asci and sometimes project slightly beyond, but never form an epithecium.

The hypothecium is the hyphal layer directly beneath the hymenium. It soon loses its hyphal nature and becomes pseudoparenchymatic, presenting the appearance of a layer of small, compact cells. This layer is usually less thick than the hymenium or the exciple and is gray hyaline.

Below the hypothecium is the excipular layer, or cortex. Three types of excipular development were observed. A palisade layer, or a modification of such a layer, is usually found. In one group of species the under surface consists of a regular, even palisade made up of large irregular hyaline cells that are formed into chains pressed closely together. The surface is occasionally broken by longer, projecting chains, but is otherwise comparatively even. The species in which this condition was observed are: *H. albella*, *H. albipes*, *H. lacunosa*, *H. monachella*, *H. pezizoides*, and *H. pulla*. Another group is represented by two species, *H. crispa* and *H. elastica*, in which the excipular layer showed extreme irregularity. The chains were grouped into pyramidal mounds, and the variation in shape and size of these chains, together with the more frequent occurrence of stray chains, produced a decidedly irregular surface. The amount of irregularity was not sufficient to form a distinct pubescence in any species except *H. pezizoides*. Lack of material for study makes it impossible to say whether or not this is a constant character for this species; it is so reported in descriptions of the species. In the third group both the palisade layer and the pyramidal mounds are lacking altogether. There is instead a loose unorganized arrangement of cells that are somewhat larger than the cells found in the hypothecium. They retain so much of the hyphal nature that it must be regarded as prosenchymatic. The outermost layer is irregularly cellular. The species in this group are: *H. californica*, *H. caroliniana*, *H. esculenta*, *H. gigas*, *H. infula*, and *H. sphaerospora*.

The color found in the fruiting head occurs principally in the

paraphyses. A small amount is sometimes seen in the excipular cells and usually gives them a sordid yellowish tint. The paraphyses of *H. lacunosa* and *H. atra* have normally a decidedly brownish color. Iodine solution does not produce in them a blue coloration.

KOH solution produces four types of color reaction in the various species. In one group the paraphyses turn bright yellow, in another, reddish brown to cinnabar-brown, in another, dark brown, and in the fourth they range in color from hyaline to sordid yellowish to pale fuscous. The bright yellow appears in *H. californica*, *H. caroliniana*, *H. gigas*, and *H. sphaerospora*; the red, in *H. esculenta* and *H. infula*. The dark brown is merely an intensification of the natural brown of *H. atra* and *H. lacunosa*, and the sordid yellowish to practically negative reaction, in which at least the tips of the paraphyses remain hyaline, characterizes the remainder of the species examined, of which *H. albipes*, *H. crispa*, and *H. elastica* are typical. The groups of species thus blocked out by means of KOH correspond roughly to groupings made on the basis of morphological data. The naturally dark-colored species, *H. atra* and *H. lacunosa*, react alike, as do the two related species *H. esculenta* and *H. infula*. In addition, *H. californica*, *H. caroliniana*, *H. gigas*, and *H. sphaerospora*, which have somewhat similar fruit bodies and an excipular development that is comparable, all show the yellow coloration. Apparently these chemically induced color distinctions conform more or less to the natural groupings.

Information gathered in the investigations just discussed has a direct bearing upon the interpretation of some of the genera in the Helvellaceae and also upon some of the species concepts. It is unnecessary to give here the complete historical account of the Helvellaceae. Many taxonomic arrangements have been put forward that involve the establishment of new genera and subgenera. The reader is referred for such material to the following sources: Anderson and Ickis (1); Banhegyi (2); Bataille (3); Beauseigneur (4); Bigeard and Guillemin (5); Boudier (7); Cooke (9); Fries (11,12); Fuckel (13); Gillet (14); Grelet (15); Hone (16); Imai (17, 18); Karsten (19); Kavina (20); Krombholtz (21); Nannfeldt (25); Phillips (26); Quélet (27); Seaver (30); and Velenovský (32).

Not all the described species have been seen by me — Seaver (30) lists only fourteen species from North America — but enough of them have been examined to enable me to vouchsafe the opinion

that the phylogeny of the group is more clearly understood and represents the natural order more accurately when the genus Helvella is considered in a broad sense. Recognizable variations exist within species, and some of the plants exhibiting them have been designated as varieties. This gradual flow of characteristics within a species, as well as between species, seems to demonstrate that a close unity exists in this group of fungi. When such a gradation of morphology can be traced, the necessity of creating many genera appears questionable. To break up the continuity of a natural progression by sharp generic barriers only tends toward confusion. The differences may be viewed as a natural progression, rather than as sharp divisions. Gyromitra, Physomitra, Leptopodia, Neogyromitra, and Globopilus are examples of genera that do not seem to be required for an accurate interpretation of this group. Neither does it appear that the creation of subgenera facilitates an understanding of the taxonomy.

One of the classic arguments involves the validity of the genus Gyromitra. Some consideration is given that question here since it concerns the position of *H. esculenta*, and also that of *H. sphaerospora*, *H. caroliniana*, and *H. gigas*, which have been placed in the genus. Gyromitra was established by Fries (12), on the basis of the gyrose cap, to take care of *H. esculenta*. This disposition separated *H. esculenta* and *H. infula*, which are shown in the present paper to be closely related, but distinct, species. The gyrose condition alone affords insufficient ground on which to maintain a genus, especially when it is realized that convolution is sometimes present in species having caps that are normally smooth, or at most wrinkled. The inclusion of *H. californica*, *H. sphaerospora*, and *H. gigas* is forced, since in these species the caps are not truly gyrose. Furthermore, the KOH reaction in these three is in sharp contrast to that found in *H. esculenta*. The evidence for and against the acceptance of Gyromitra is set forth by Seaver (29), by Anderson and Ickis (1), and by others. It suffices to say that I prefer to use the genus Helvella in the broad sense, as defined by Seaver (30).

The question whether or not the two species *H. infula* and *H. esculenta* are synonymous is also of long standing. From a careful study of both fresh and herbarium material I am convinced that the two are undoubtedly distinct. A fine collection of fresh fruit bodies was examined. It consisted of more than one hundred caps found

growing under *Populus grandidentata* and *Abies balsamifera* at Lupton, Michigan, May 2, 1946. They were collected by A. H. Smith (no. 21388). The dried specimens examined came from New Hampshire, Michigan, Montana, Oregon, Washington, Canada, and Sweden. These collections, too, had been made in the spring, and all the specimens had been found growing under conifers. These are two circumstances that contrast sharply with the conditions characteristic of *H. infula*, which is collected in summer and early fall in localities where only deciduous trees are present. In fact, the fruit bodies of this species are often found growing directly upon decayed wood of deciduous trees. In addition to these differences in season of growth and in habitat, there is a marked difference in the shape and stature of the fruit bodies in the two species. *H. infula* tends to be tall and slender, with a saddle-shaped cap. *H. esculenta* is a stouter plant, with a thicker stipe and a decidedly gyrose cap. The colors differ, too, for *H. infula* is usually some shade of tan or light brown, whereas the caps of *H. esculenta*, when fresh, range from "cinnamon-buff" (R.) [1] through "bay" to "chocolate," "Mikado brown," and "Hessian brown," the stipes being "buff pink" to "vinaceous tawny." But the principal difference is in spore shape and spore size. Freshly shed spores of *H. esculenta* measure $24–28 \times 12–16\ \mu$ and are decidedly ellipsoid. They contain two bright oil drops, one at each extremity of the spore. On germination the oil drops break down, and when the germ tube is $50\ \mu$ or less long all trace of globules is gone. The spores of this species revived in KOH were similarly ellipsoid, and were likewise consistently different in shape from those in *H. infula*, but they were slightly smaller than the spores from the fresh fruit bodies. The spores in *H. infula* are narrowly oblong and measure only $16–18 \times 7–8\ \mu$. The forty-two collections of *H. infula* examined represent a wide distribution in the United States.

There is another confusing situation, involving *H. gigas* and *H. caroliniana*. Krombholtz (21) described and illustrated *H. gigas* as having smooth spores, but Seaver (29) put it in synonymy with *H. caroliniana*, which is a rough-spored species, and Boudier (6) made a similar error in illustrating *H. gigas* with rough spores. Bresadola (8) gives the correct interpretation of this species. Nann-

[1] Color terms quoted are from R. Ridgway, *Color Standards and Color Nomenclature*, 1912.

feldt (24) and Imai (17) concluded that *H. gigas* Krombh. does not occur in the United States. The Herbarium of the University of Michigan has collections of both these species; those of *H. gigas* were made in Idaho and Michigan, and those of *H. caroliniana*, in Illinois, Michigan, Ohio, and Tennessee. The spores of these collections of *H. gigas* measure 30–35(40) × 11–12(14) μ and are smooth. The spores of the Michigan Herbarium collections of *H. caroliniana* measure 26–34 × 14–16 μ, are sometimes apiculate, and are decidedly roughened by warty protuberances. The species is easily recognized by these rough spores.

Another question is raised concerning the two species *H. caroliniana* and *H. underwoodia* Seaver. The descriptions of the two are nearly identical. Seaver (30) separates them upon the assumption that the spores of *H. caroliniana* are strongly apiculate and that those of *H. underwoodia* are not. Collections of *H. caroliniana* spores have been examined, and both apiculate and nonapiculate spores have been found in the same fruit body. It is evident, therefore, that *H. underwoodia* becomes a synonym of *H. caroliniana*.

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THE APPLICATION OF ZALENSKI'S LAW TO CERTAIN SUBMERGED PLANTS *

MARION I. LEHNER

THE measurements and observations of leaves of upright terrestrial plants made by V. Zalenski and published in Russian in *Kiev Politekhnicheskii Institut Izvĕstiĭa*, 4: 1–203, in 1904, as reported in Maximov (6), have established the general rule that "the anatomical structure of the individual leaves of one and the same shoot is a function of their distance from the root system." Maximov (6) states: "This may justly be called Zalenski's law." Zalenski (*fide* 6 and 7) found that upright terrestrial plants have a tendency to show a more xeromorphic structure in the upper leaves than in the lower ones. Among the conditions he observed were a decrease in the size of vein islets, epidermal cells, and guard cells, and a greater frequency of stomates per unit of surface in the upper leaves.

Since it is accepted as a fact that the ancestors of flowering aquatic plants were terrestrial plants and since Zalenski and others (2, 6, 7) worked on upright terrestrial species which were subjected to the increasing drying effects of the atmosphere, certain long-stemmed submerged species of Potamogeton were chosen for study because they live under conditions of greatly reduced "transpiration." The purpose of this study was to see whether the tendency observed by Zalenski can be found in submerged aquatics also. He (*fide* 6) and Yapp (8) believe the fundamental reason for this xeromorphy of upper leaves may be the reduction in the amount of water available because of interception by lower leaves. Zalenski's findings have been confirmed by the works of Yapp (6), Heuser (*fide* 6), Rippel (*fide* 6), Miller (7), and others.

* The investigations upon which this paper is based were conducted during July and August of 1941 at the Biological Station of the University of Michigan at Douglas Lake, Cheboygan County, Michigan.

The author acknowledges her indebtedness to Dr. Frank C. Gates and Dr. Carl D. La Rue for suggesting the problem and for assistance in its completion.

METHODS

The stems of *Potamogeton richardsonii* (Benn.) Rydb. and *P. praelongus* Wulf. were found to be the longest of the long-leaved species growing in Douglas Lake. Fifty-six plants were collected for study from water about twenty feet deep just beyond the dropoff on the southeastern shore of the lake. Since it was difficult to obtain specimens with roots, measurements were begun at the apex. The first mature leaf and the lowest leaf were selected, together with intermediate leaves at distances approximately one meter apart. Distances between these leaves were measured. A section about one centimeter square was cut from the median portion of each leaf (Fig. 1). This was mounted on a slide in a drop of lactic acid and placed in an oven at 50° C. for twenty-four to forty-eight hours, or until it was cleared. Measurements of lower epidermal cells were made by use of the ocular micrometer at a magnification of 440×. Ten cells were measured in each of three locations — at the margin and at the intermediate and central positions on the leaf (XXX in Fig. 1). These leaves were then classified into one-meter groups, starting at the tip. Measurements of ten vein islets were made with a Spencer projectoscope at a magnification of 12.5×. The cells were found to be somewhat rectangular, and so measurements of length and width were taken along lines intersecting at right angles in the center (Fig. 2). Photomicrographs of typical cells and of typical vein islets are illustrated in the figures of Plate I.

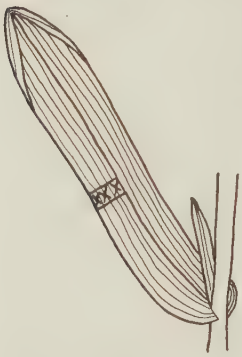

FIG. 1. *Potamogeton praelongus*, a leaf showing method of sampling

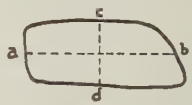

FIG. 2. Typical central epidermal cell, showing location of measurements. *a–b*, width of leaf; *c–d*, length of leaf

The complete data, which are much too lengthy to be included in this paper, have been filed in the library of the Biological Station at Douglas Lake and are available for study. The form used to record the data is shown in Table I. A summary of the total number of measurements taken is shown in Table II.

TABLE I

EXAMPLE OF THE METHOD USED TO RECORD THE MEASUREMENTS TAKEN ON EACH LEAF

Potamogeton praelongus, specimen 18, leaf 20.

Distance between nodes	Epidermal cells (ocular units*)						Vein islets†	
	Marginal		Intermediate		Central			
	Length‡	Width	Length	Width	Length	Width	Length	Width
71 cm.	11.5	3.5	5.0	11.5	4.5	8.0	38.0	13.0
	7.5	4.0	3.5	6.0	4.0	9.0	43.0	7.0
	10.0	3.5	2.5	5.5	3.5	9.0	69.0	19.0
	13.0	4.5	4.0	11.5	3.5	8.0	56.0	20.0
	11.0	3.5	3.5	11.5	3.5	9.5	4.0	21.0
	11.0	4.0	3.5	11.5	4.5	8.0	45.0	22.5
	11.0	3.5	3.5	10.5	3.5	9.0	5.0	17.0
	7.0	4.5	4.5	5.0	3.5	9.5	118.5	17.0
	9.0	4.0	2.5	5.5	4.0	9.5	63.0	16.0
	13.0	4.0	5.0	11.5	3.0	9.0	45.0	14.0
Average	10.4	3.9	3.75	9.0	3.7	8.85	55.2	17.6

* Ocular unit = 3.27 microns. Magnification 440×.

† 1 mm. projected = 12.5 mm. on screen.

‡ Measurements made with reference to shape of leaf, "length" being parallel to length of leaf and "width" to width of leaf.

The probable error was computed by methods and tables taken from the *Handbook of Chemistry and Physics* (5), which states that "the probable error of a series of n measurements a_1, a_2, a_3, $---a_n$, the mean of which is m," can be expressed by the following approximate equations, which are convenient forms of computation:

$$\text{Probable error of the series is } 0.8453 \frac{\Sigma d}{\sqrt{n(n-1)}}.$$

$$\text{Probable error of the mean is } 0.8453 \frac{\Sigma d}{n\sqrt{n-1}}.$$

The symbol Σd represents the arithmetical sum of the deviation from the mean.

If three times the probable error is less than the difference between the mean of the first group and that of the second group, the figures may be said to show a significant difference. Measurements

TABLE II

A Summary of the Number of Measurements Taken

Distances from tip	Cells measured						Vein islets measured	
	P. richardsonii			*P. praelongus*			*P. richardsonii*	*P. praelongus*
	Marginal	Intermediate	Central	Marginal	Intermediate	Central		
Less than 1 meter	420	420	420	340	340	340	420	340
1–2	360	360	360	270	280	280	360	280
2–3	410	420	420	70	70	70	420	70
3–4	60	60	60	*	*	*	60	*
Total per species	3,770			2,060			1,260	690
Grand total	5,830						1,950	

* No specimens were longer than three meters.

of the areas of epidermal cells and of the vein islets and the probable errors of each are given in Table III.

A comparison of the measurements of the areas of the cells and of the vein islets can best be made by determining the probable error of the differences, which can be computed by use of the formula

$$V = \frac{D}{\sqrt{(p.e.m.)^2 \sqrt{(p.e.M.)^2}}},$$

in which V is the value of the difference and D is the difference between the two means m and M. If V is three or less, the difference between the two means is probably not significant. By examination of Table III it will be seen that only two of nine measurements of areas of cells and two of three measurements of areas of vein islets of *Potamogeton richardsonii* are significant, and four of six cells and one of two vein islets of *P. praelongus* are significant.

TABLE III

A Summary of Areas Taken from Averages of Measurements of 5,830 Cells and 1,950 Vein Islets

Probable error of the mean and differences.
Measurements of cells are in microns and vein islets in millimeters projected.

Distances from tip		Epidermal cells			Vein islets
		Marginal	Intermediate	Central	
Potamogeton richardsonii					
Less than 1 meter (42 specimens)	Mean	163.0 ± 3.06	69.3 ± 1.78	82.3 ± 2.72	93.3 ± 10.10
1–2 (36 specimens)	Mean	201.0 ± 4.00	85.4 ± 2.11	79.4 ± 1.92	32.9 ± 1.17
	Diff.*	38.3 ± 7.62	16.1 ± 0.15	2.91 ± 0.008	60.4 ± 0.61
2–3 (42 specimens)	Mean	216.0 ± 5.96	89.6 ± 1.81	104.0 ± 2.36	45.5 ± 1.31
	Diff.*	14.7 ± 0.51	4.16 ± 0.03	24.8 ± 0.19	12.6 ± 7.11
3–4 (6 specimens)	Mean	167.0 ± 6.97	80.5 ± 3.15	82.7 ± 4.23	38.2 ± 3.30
	Diff.*	49.0 ± 0.53	9.1 ± 2.50	21.5 ± 4.44	7.23 ± 3.55
Potamogeton praelongus					
Less than 1 meter (34 specimens)	Mean	140.0 ± 0.178	87.0 ± 2.33	103.0 ± 2.16	46.7 ± 2.35
1–2 (28 specimens)	Mean	153.0 ± 2.93	102.0 ± 1.85	131.0 ± 5.29	52.5 ± 1.57
	Diff.*	13.6 ± 4.64	15.0 ± 5.03	27.4 ± 4.66	5.78 ± 2.44
2–3 (7 specimens)	Mean	179.0 ± 7.95	107.0 ± 8.21	152.0 ± 14.90	49.3 ± 3.75
	Diff.*	25.7 ± 3.03	5.03 ± 0.59	11.3 ± 0.51	3.27 ± 0.80

* Difference between this group and the preceding one.

DISCUSSION

The leaves of *Potamogeton richardsonii* and *P. praelongus* were thin and easily cleared for study. The presence of chloroplasts, which were found in the epidermis, was thought to be due to the reduced amount of light available to submerged plants (1). The cells of the epidermis are somewhat rectangular, a shape thought by E. Mer (*fide* 1) to be due to a constant state of turgescence because of the feeble "transpiration" of submerged plants, which allows a more uniform growth. Stomates or their vestigial indications were not found in the epidermis of the specimens studied.

Until Zalenski's study (*fide* 6) it was supposed that plants living in a dry environment were protected against excessive evaporation and that they had no need of a rapid water supply. It was also supposed that plants living under conditions of high humidity had structural adaptations for increased transpiration. Zalenski observed in 1901 (*fide* 6) that the network of veins was better developed in the leaves of plants growing in open habitats than in those of plants growing in the higher humidity of woodland shade. He also found that the upper and lower leaves of plants growing under these conditions sometimes showed no difference in density of venation. *Potamogeton richardsonii* and *P. praelongus*, being submerged aquatics living under conditions of low rate of "transpiration," showed no consistent decrease in areas of vein islets from the lowest to the highest leaf.

Since the constant decrease in size of cells and vein islets observed by Zalenski (*fide* 6) and others (2, 3, 4, 7) in upright terrestrial plants was not obtained in the submerged aquatics which were not exposed to the increasing drying effects of the atmosphere, the data gathered would seem to indicate that there must be other environmental factors not taken into consideration, that environment is a greater controlling factor than heredity, and that indirectly they are a confirmation of Zalenski's law.

SUMMARY

1. This investigation shows no consistent increase in size of lower epidermal cells or vein islets from apical to basal leaves of *Potamogeton richardsonii* and *P. praelongus*.

2. The data gathered from observations upon these aquatic species are not in agreement with observations made by Zalenski and others on terrestrial species.

3. The data may be interpreted to mean that environment has a greater influence than heredity in determining the size of cells and vein islets in the aquatic flowering plants studied.

4. It may be said that the observations indicate indirectly a confirmation of Zalenski's law.

Pontiac, Michigan

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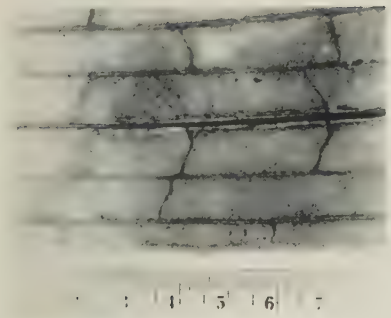
PLATE I



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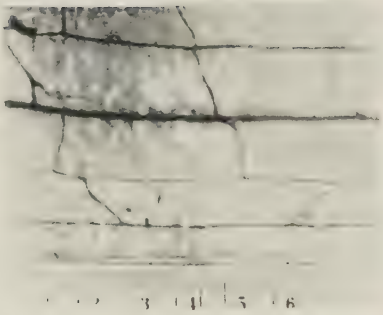

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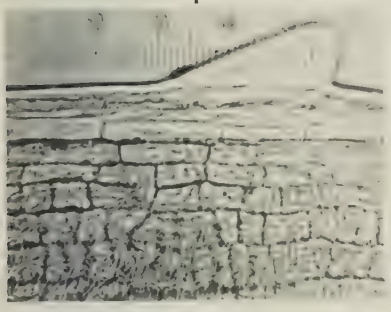

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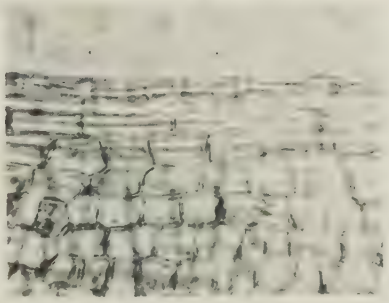

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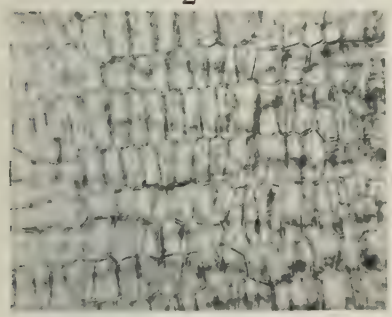

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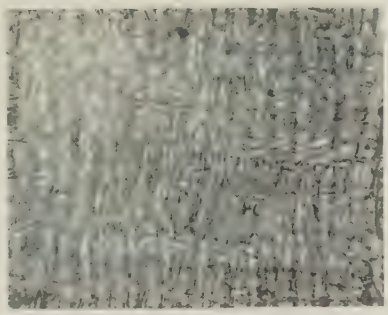

6

Fig. 1. Vein islets, *Potamogeton richardsonii*. × 12.5
Fig. 2. Marginal cells, *P. richardsonii*. One ocular unit. 3.27 μ
Fig. 3. Central cells, *P. richardsonii*
Fig. 4. Vein islets, *P. praelongus*. × 12.5
Fig. 5. Marginal cells, *P. praelongus*. One ocular unit. 3.27 μ
Fig. 6. Central cells, *P. praelongus*

STUDIES IN THE GENUS PORIA*

I. *PORIA CARNEOPALLENS* (BERK.) COOKE

JOSIAH L. LOWE

STUDY of Poria material now in the Farlow Herbarium from the southern United States and from the tropical regions of the Western Hemisphere revealed that widespread confusion existed concerning the identity of *Poria carneopallens*. The type collection alone of the specimens listed below was filed under its proper name, and an adequate idea of the distribution and incidence of this species depended upon a search for and restudy of the pertinent herbarium specimens.

The macroscopic and many microscopic characters of *Poria carneopallens* are closely similar to those of the common and widely distributed *Poria eupora* (Karst.) Cooke. The ranges of these two species overlap, and their close similarity has led to much confusion. The spore size and shape readily separate them (Fig. 1 a, b), but southern material proved sterile more often than fertile. For this reason a character for the specific identification of sterile specimens was sought and found.

Positive distinction between these two species can be made by determining the nature of the thin-walled connective hyphae in the subiculum. In *Poria carneopallens* septa are regularly present but clamp connections are lacking, whereas clamp connections are regularly present on such hyphae in *Poria eupora*. It must not be supposed that septa or clamps are always readily seen, for in both species connective tissue may be so scanty and may break into such minute pieces on crushing that an oil-immersion lens frequently must be employed to observe this character. In so far as fertile material

* Contribution from the Department of Forest Botany and Pathology, The New York State College of Forestry, Syracuse, New York, and from the Farlow Reference Library and Herbarium of Cryptogamic Botany at Harvard University, Cambridge, Massachusetts.

This study was supported in part by a grant-in-aid from the Society of the Sigma Xi.

provided a check, however, the taxonomic value of this character proved diagnostic.

Since a complete and modern description of *Poria carneopallens* has not been published, one is here appended.

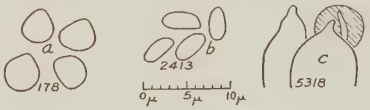

FIG. 1. Spores and cystidia in species of Poria: *a*, spores from the type collection of *P. carneopallens; b*, spores of *P. eupora* (from Lowe 2413); *c*, mammillate cystidia from original material of *P. fulvobadia* (no. 5318). A cross section of a cystidium showing the very thick walls is at the upper right

Poria carneopallens (Berk.) Cooke, *Grevillea*, 14 : 110. 1886

Polyporus (*Resupinatus*) *carneopallens* Berk., *Hooker's Journ. Bot.*, 8 : 237. 1856.

Fruiting body annual, effused up to 10 cm., inseparable, without distinctive taste. Margin whitish to cream, narrow, appressed-tomentose. Pore surface varying from pale cinnamon to flesh color, faintly glancing, the tubes tough and somewhat cartilaginous when dry, up to 1 mm. long, the mouths angular, variable in size from 8 to 12 per mm., the edge narrow, entire, often whitened. Subiculum cream, up to 0.3 mm. thick, firm-fibrous.

Sections not changing color in potassium hydroxide solution, the fundamental hyphae of the subiculum rarely branched, nonseptate, 4–7 μ in diameter, and the connective hyphae abundant to rare, thin-walled, septate, and 2–4 μ in diameter. Cystidia abundant to rare, terminally incrusted, 7–11 μ in diameter; basidia clavate, 11×4–6 μ; spores hyaline, smooth, ovoid to subglobose, often with somewhat flattened sides and appearing more or less triangular, $3.5 - 4 \times 2.5 - 3.5$ μ.

On the wood of deciduous trees, associated with a white rot. Specimens studied in the Farlow Herbarium: Brazil, Spruce 178, type collection; Cuba, W. L. White 376, 854, 858; Florida, R. Thaxter 90, and W. W. Calkins 792.

Poria fulvobadia Pat. (*Journ. Botanique*, 11 : 340. 1897) from Tonkin, French Indo-China, agrees in all the characters described

above and has, in addition, peculiar mammillate cystidia shown in Figure 1 c. Such cystidia were found in the type of *Poria carneopallens* after this manuscript was submitted for publication, and it seems certain that these two species are synonymous.

This species has also been reported from Brazil by Berkeley and Cooke (*Linn. Journ. Bot.*, 15 : 384. 1876), Bresadola (*Hedwigia*, 35 : 282. 1896), Hennings (*Hedwigia*, 43 : 199. 1904), and Theiszen (*Kaiserlich. Akad. Wissensch. Wien, Math.-naturw. Kl., Denkschr.*, 83 : 239. 1911); from Cuba by Berkeley and Curtis (*Journ. Linn. Soc. London*, 10 : 318. 1868) and by Murrill (*Mycologia*, 11 : 22. 1919); from Guadeloupe and Martinique by Duss (*Flore cryptogamique des Antilles françaises*, p. 238 (or 28). 1904), as Leptoporus; from Nicaragua by Ellis and MacBride (*Bull. Lab. Nat. Hist. State Univ. Iowa*, 3 : 191. 1896) and by C. L. Smith (no. 81, Central American Fungi, 1896 — Farlow Herbarium specimen sterile and uncertain); from Paraguay by Spegazzini (*Bol. Acad. Nac. Cienc. Córdoba*, 23 : 425. 1919); from Venezuela by Patouillard (*Bull. Soc. Myc. France*, 4 : 35. 1888).

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NEW AND INTERESTING SPECIES OF BASIDIOMYCETES. II *

ROLF SINGER

DURING a period of five years (1940–45) a large number of new and incompletely known species of Basidiomycetes from many parts of the world have accumulated "in schedulis" and in my notebooks. Some of these have appeared in the first part of this paper, and more will be published in future supplementary series.

VIII. Two New Boletes

Suillus ruber Sing. & Sipe sp. nov.

Pileo laete rubro, maculis obscurioribus adsperso, viscido, subfibrilloso-verruculoso in siccis, maculis sordide carmineis, interstitiis pallidis, forma magnitudineque *Boletum pictum* aemulante. Hymenophoro viridulo-flavo in maturis, poris tubulisque in siccis colorem eorum *Suilli tomentosi* (Kauffm.) Sing. (*Boleti tomentosi* Kauffm.) simulantibus, poris angustis, vix amplis, adnatis; sporis pallide melleis vel melleis, paucis castaneo-brunneis, levibus, depressione suprahilari carentibus, tenuitunicatis, 7.8–9.8 × 2–3.4 μ; basidiis 20–21 × 5.5–6.2 μ, tetrasporis; cystidiis aut 24–32 × 4.8–5.2 μ, hyalinis, fusoideis, aut usque ad 50 × 7.5 μ, brunneo-incrustatis, clavatis, ambobus typis in eodem hymenophoro constanter praesentibus, secundi typi cystidiis in maculis minutissimis concentratis. Stipite flavo, glanduloso, solido, apicem versus subattenuato, evelato; glandulis e dermatocystidiis versiformibus, plerumque fusoideo-cylindraceis vel fusoideo-subampullaceis, fortiter castaneo-incrustatis, confertissimis, 35–85 × 4.5–12.5 μ consistentibus; elementis aliis heterogenis (dermatocystidiis typi alterius,

* The first part of this paper appeared in *Mycologia*, 37 : 425–439. 1945.

The color terms used in this paper are those of Richard Crawshay, *The Spore Ornamentation of the Russulas* (London, 1930); A. Maerz and M. Rea Paul, *Dictionary of Color* (New York, 1930); R. Ridgway, *Color Standards and Color Nomenclature* (Washington, D.C., 1930); E. Séguy, "Code universel des couleurs," *Encyclopédie pratique du naturaliste*, XXX (Paris, 1936).

dermatopseudoparaphysibus, dermatobasidiis) nullis vel perpaucis visis. Carne in pileo alba, in stipite flava, caerulescente in ambobus quando fracta est; odore nullo notabili; sapore miti. Sub coniferis (*Picea Engelmannii* et *Pino Murrayana* cum qua probabiliter mycorrhizam format). Septembri mense. Odell Creek, Oregon, U. S. A. occidentalis, America Borealis. F. P. Sipe, 333 (FH). Vide Pl. I. Inter Granulatos Sing. pileo rubro unica species, atque carne caerulescente eximie distincta est; fortiter e Hirtellinis.

Xerocomus indicus Sing. sp. nov.

Pileo flavo, tomentuloso, pulvinato, levi, 10–20 mm. lato; cuticula ex hyphis filamentosis, plus minusve gelatinescentibus composita. Hymenophoro tubuloso, haud convexo; tubulis concoloribus cum pileo, longis, adnatis vel decurrentibus, poris concoloribus, pro ratione amplis, angulatis; sporis olivascente-brunneis in cumulo, sub microscopio melleis, parvulis, 5–6.5 (7.5) × 3.2–3.5 (3.7) μ, levibus, depressione suprahilari subnulla; basidiis tetrasporis; cystidiis parvulis, sparsis; tramate in adultis typi Phyllopororum. Stipite subconcolori vel magis brunnescente, pro ratione firmo, subglabro, solido, subaequali, pilei diametro longiore, tenui; mycelio sparso, flavo. Carne subconcolori cum superficiebus; odore saporeque haud notatis; hyphis fibulis destitutis. In terra sub *Saccharo manja* Roxb. Ladhar St., India Orientalis. Sultan Ahmed, 44 (FH).

Observations. — The present collection does not afford an opportunity to examine the structure of the young stages, yet a comparison with *Xerocomus brasiliensis* (Rick) Sing. shows that these species must be extremely close, apparently belonging to the same section (Brasilienses Sing.). It cannot be established at present whether the pileus is ever viscid in fresh condition, but it may be assumed that it is. The main difference between this and *X. brasiliensis* is the smaller spores of *X. indicus*.

RUSSULACEAE

IX. The Genus Lactariopsis Henn.

The group of agarics belonging in Lactariopsis was characterized by R. Heim in 1938 and by me in 1942, its status in both accounts being lowered to subgenus or section (of Lactarius). But in 1941

I received a collection of African fungi for determination among which were the original *Lactariopsis Zenkeri* Henn. (which is closely related to *Lactarius Pandani* Heim) and, also, a gymnocarpous species closely related to *Lactariopsis Zenkeri*. I was preparing this manuscript, in which I regarded the gymnocarpous species as new, belonging to an emended section Lactariopsidei (Henn.) Sing. (or Lactariopsis [Henn.] Heim as subgenus), when a set of papers published by R. Heim during the war reached me. Heim had, in one of these articles, not only described the same species (though without a Latin diagnosis, which is now supplied) that was deposited here under a new herbarium name, but also emended Lactariopsis much as I had intended to emend it. Heim says (*Boissiera*, 7:276. 1943): "On peut établir ce sectionnement, croyons-nous, sur l'existence d'un *revêtement* persistant, pileux ou membraneux, sur celle de *cystides* faciales, et secondairement sur des spores ovoides-ellipsoides à ornementation du type finement réticulé-verruqueux, enfin à l'habitat lignicole (bois mort) ou propre à un humus ligneux."

KEY TO THE SPECIES OF LACTARIUS, SECTION LACTARIOPSIDEI

A. Pileus up to 30 mm. broad, without radial folds or veins; veil annular in most instances; Cameroons and Liberia
Lactarius Zenkeri (Henn.) Sing.

A. Pileus larger; surface with radial folds or veins; veil annular or appendiculate or wanting
B. Veil present; odor none; Madagascar ..... *Lactarius Pandani* Heim
B. Veil none; odor disagreeable; Côte d'Ivoire, Haute-Guinée, Liberia, Cameroons ..... *Lactarius gymnocarpus* Heim

I have nothing to add to the description of *Lactarius Pandani* Heim; see *Les Lactario-Russulés du domaine oriental de Madagascar* (Paris 1938), page 37.

Lactarius Zenkeri (Henn.) Sing., Ann. Mycol., 40:111. 1942

Lactariopsis Zenkeri Henn., Engler's Bot. Jahrb., 30:51. 1901.

Pileus red brown with light-colored margin in button stage, then orange brown at the center, light tan at the periphery, floccose-pubescent, with the margin at first involute, then repand and striate, convex with a slight depression in the center, becoming gradually

flatter or even infundibuliform in some specimens, 10–30 mm. broad. Lamellae cream-colored, then light tan, dirtier when bruised but not actually changing color, close, adnate, rather narrow (1–3 mm. broad); spore print not obtained. Stipe cream-colored at the apex, light tan below, flocculose, subequal or tapering downward, spongy-solid, 25–35 × 3–6 mm.; veil connecting the incurved margin of the pileus with the apex of the stipe and later forming an apical annulus in most specimens.[1] Context cream-colored in pileus and stipe; latex probably sparse (not noticed by the collector); odor disagreeable.

Spores 8.5–12 × 7.5–10.5 μ (rarely reaching the upper limit), with ornamentation 0.5–1.2 μ high, consisting of warts or cylindric spines connected by fine lines, type IIIa in mature spores, but in young spores type I or II, with the hilar appendage far off the lower axial pole, hyaline, oil droplet small or, more often, large; basidia 31–38 × 9–15 μ, 4-spored; cystidia 68–110 × 10.5–16 μ, with scattered to coarsely massed (as in *Russula congoana*), banded contents, usually subcylindric with one or two ventricose thickenings at the base and near the apex, more rarely equal or clavate, the apex sometimes with a granular crystalline incrustation; cuticle of pileus beset with an outer layer of hairs, these hairs thick-walled, subulate, nonpseudoamyloid, nonamyloid, with obtuse or subacute apex, with a double wall (the external one about 0.5 μ thick, the internal one 1.5–2.5 μ thick; later the entire wall reaching 3.5 μ), 35–300 × 5–9 μ; gill trama consisting of laticiferous hyphae, other hyphae inconspicuous in young specimens, later with many connective hyphae which are, however, often irregularly inflated and sphaerocystoid, but the trama not truly heteromerous except for the upper (thicker) end of the lamellae near the flesh of the pileus in old specimens; mycelium consisting of thick-walled, hyaline, clampless hyphae; veil consisting of thin-walled, thin, flexuous hyphae, which at the surface often merge into thick-walled hairlike hyphae, all hyaline; context of the stipe truly heteromerous from the beginning, consisting of rather large sphaerocysts (e.g. 55 μ in diameter) and connective hyphae; all hyphae without clamp connections.

Habitat and distribution. — On humus and well-rotted wood,

[1] If Heim's drawing (*Les Lactario-Russulés*, p. 43, fig. 11) of the Madagascar species (*L. Pandani*) is compared, it should be noted that the line of rupture is along A—B in *L. Zenkeri*.

densely gregarious to clustered, during the early rains (April). Cameroons (type locality) and Liberia (near Nengbe), G. W. Harley, 57.

Lactarius gymnocarpus Heim (cf. Boissiera, 7: 273, fig. 27. 1943, sine diagnose Latina)

Pileo radialiter venoso, subflocculoso-tomentuloso, aurantiaco-brunneo, subaurantio ad marginem, c. 75 mm. lato; cuticula crinibus crasse tunicatis obsita. Lamellis cremeo-albidis, subdecurrentibus, distantibus, heterophyllis, dimidiatis intermixtis, 10 mm. latis, ceraceis, tenuibus; sporis albis, sub microscopio hyalinis, 7.7–11 × 6–8.5 μ, ornamentatione 0.3–1.4 μ alta, subcristulata vel verruculoso-reticulata, asymmetrice hilatis; basidiis tetrasporis, rare bisporis; cystidiis fusoideis vel subclaviformi-filamentosis, acutis vel obtusis; tramate lamellarum sphaerocystis sat numerosis praedito. Stipite pileo concolori ad apicem, ad basin albostrigoso, vestito sicut pileus, spongioso-molli-subfragili, versiformi, base saepe sulco angustiore a parte altera separata. Carne in pileo alba, in stipite cremea; latice albo; sapore miti; odore ingrato. In humo lignoso. Africa tropicalis occidentalis (Côte d'Ivoire, Haute-Guinée, Liberia, Cameroons).

Observations. — In the Liberian specimens the veins of the pileus were anastomosing; the wall of the hairs of the epicutis was 1–5 μ thick, thicker toward the base of the hairs, the hairs forming a palisade on the umbilicate, plane pileus; the spores were of two rather sharply separated types, either large (9–11 × 7.5–8.5 μ) with high ornamentation (0.8–1.4 μ) or small (7.7–9 × 6–7.5 μ) with lower warts or ridges (0.3–0.4 μ); these spores were found in the specimens at the same time, and both evidently belonged to the common carpophore; the smaller ones were in the majority. The latter type must have been retarded in their development, for this is probably not a specific character. The type of ornamentation was, as may be expected, also rather variable in the Liberian specimens (II, IIIa, IIIb, IV). The stipe was about 40 × 10 mm. The plant grew on humus in the tropical forest, solitary.

R. Heim must choose a type specimen. According to him, the pileus can reach 175 mm. in diameter, the cuticle is nonseparable, there are 14–22 lamellae running out on the stipe into longitudinal veins, and the stipe is tuberculate-scrobiculate besides; the flesh

stains black or brown in a rather inconstant manner; the latex is serifluous, unchanging, and mild; $FeSO_4$ turns the context of the pileus a bright blue green.

X. A South American Representative of Russula, sec. Pellicullariae

Russula brasiliensis Sing. sp. nov.

Pileo fusco, glabro, convexo, margine late (per tertiam marginalem radii) pectinato-fisso Coprinorum modo, acutiusculo, 40–50 mm. in diametro in statu vegeto aestimato; dermatocystidiis nullis visis; lamellis subangustis, subaequalibus, simplicibus, venis transversalibus connexis, liberis vel subliberis; sporis albidis aestimatis (verosimiliter plus minusve B Crawshayi), sub microscopio subglobosis, c. 10.5 μ in diametro, ornamentatione cristato-reticulata (typi I, mox II–IIIa–IIIb, cristulis cuneatis verrucisque 1.5–2 μ altis), membrana melleo-hyalina (subhyalina) praeditis, subsymmetricis *Russulae annulatae* modo; basidiis c. 38 × 13 μ; cystidiis versiformibus, membrana plerumque plus minusve incrassata instructis (0.5–1.1 μ), compluribus granulatione flavida impletis, 50–65 × 12–13 μ. Stipite subconcolori vel albido (discolorato siccando), tenui, subaequali vel ad apicem attenuato, ad basin indistincte discoideo vel haud discoideo, exannulato. Carne pallida, exsiccatione leniter fuscata; odore saporeque haud indicatis. In terra sabulosa. Rio Grande do Sul, Brasilia. J. Rick (ut *Russula pectinata*), Herbarium Patouillard (FH).

Observations. — This species is similar to *Russula pectinata*, which is common in North America south to tropical south Florida and perhaps to Brazil. The specimen studied, however, which was sent to Patouillard by Rick as a sample of what he called (and published as) *R. pectinata*, is not that species because of the entirely different spores and surface characters. It belongs in the subsection Discopodinae Heim of the section Pellicullariae Heim, whose representatives have thus far been collected in Africa only. The subsymmetrical spores are very much the same as those found in the Discopodinae, and it is mainly the color of the carpophore (not bright-colored anywhere) that distinguishes the Brazilian species from the African ones. *R. brasiliensis* differs from *R. annulata* var. *exannulata* Heim in the color of the pileus, the less developed or not developed basal disc, the sometimes thick-walled cystidia, and probably in other

characters not now obvious because of the lack of notes on the fresh specimens.

The structure of the cuticle of this species in unexpectedly complicated. The uppermost layer (epicutis) is composed of hairlike elements, some of which usually consist of elongated members of 4–5.5 μ in diameter, which contain amorphous or, even, banded contents. These elements form a palisade immediately upon the lower layer. The subcutis is made up of interwoven, hyaline hyphae running in all directions, embedded in a gelatinous mass, and very loosely arranged; no clamp connections are present. Beneath the subcuticular layer there is a third layer of pigmented hyphae which are more regularly tangentially arranged, subparallel, denser, and not gelatinized; then, farther below, the context of the pileus, intermixed with numerous sphaerocysts, begins. The layer of pigmented hyphae corresponds to what is usually called "hypoderm" in the Agaricales (but not in the Russulaceae). I think that the term "hypoderm" would be correct in this case, and should be applied generally if the infra-epicuticular layer is divided into two strongly differentiated zones.

XI. A New Species of Russula, sec. Compactae, subsec. Nigricantinae

Russula albonigroides Sing. sp. nov.

Pileo livescenti-griseo-fusco, dein atrofusco, levi, udo, concentrice canaliculato in compluribus, convexo, demum concavo, cuticula glabra, adnata margineque acutissimo, levissimo, tenui gaudente, 35–70 mm. lato; cuticula pilei submonostrata, ex hyphis irregulariter dispositis, fuscatis, levibus, filamentosis, 2–9 μ crassis consistente; sub cuticula sphaerocystis carnis obviis (e.g. 60 μ in diametro). Lamellis pallide alutaceis in maturis, nigricantibus, 3 mm. latis, angustioribus carnis crassitie aut aequantibus eam, confertis vel confertissimis, de centro radii pilei angustatis intus extusque, tenuibus, subdecurrentibus; sporis 7.7–9.5 × 6.5–7.5 (7.7) μ, asymmetricis, ellipsoideo-globulosis, hyalinis, ornamentatione reticulata areas polygonas delimitante, 0.5–1.5 μ alta (i.e. elatissima), typi II–IIIa vel I, spinulis, ubi exstant, plerumque cylindraceis, crassiusculis; basidiis 35–43 × 9.5–12 μ, tetrasporis, subinde fusoideis at plerumque clavatis; cystidiis 58–78 × 6.5–9 μ, hyalinis vel fuscatis in siccis, e tramate radicantibus, subfusoideis vel fusoideis aut subclavatis, saepe

capitatis vel appendiculato-capitatis, nonnullis intus vermiformiter granulosis; tramate subvesiculoso (sphaerocystis abundantibus). Stipite griseolo, nigrescente, evelato, cylindraceo, circa 40 × 15 mm. Carne alba, in stipite sordide albida, fracta nigrescente, in siccis nigra, in pileo submolli, in stipite dura; odore nauseoso; sapore ignoto, probabiliter haud fortiter acri; hyphis defibulatis. In silvis tropicalibus sparse. Jove sicciore. Ganta, Liberia, April 19, 1939. G. W. Harley, 77, typus (FH), et Tjibodas, Java, 1908, F. v. Höhnel (FH).

Observations. — The specimen from Java is preserved in the Höhnel Herbarium, and is determined by Höhnel as "*Russula adusta*? — kaum etwas anderes." Here the spores are slightly smaller, but far from comparable with spores of *R. adusta*.

XII. More New Tropical Russulae

Russula Hoehnelii Sing. sp. nov.

Pileo flavido vel pallide brunneolo-ochraceo in maturis, ochraceo-brunneo in siccis, sicco, verruculoso, verrucis densioribus coloreque saturatiore centrum versus ubi superficies subintegra videtur, interdum subsquamoso-rupto, rugoso-costato supra dorsum lamellarum, convexo centro depresso, 33 mm. lato in siccis; epicute e crinibus ascendentibus, versiformibus, ad apicem rotundatis, levibus, hyalinis, intus haud granulosis, 3.5–6 (9) μ latis consistente; subcute ex hyphis plus minusve tangentialiter dispositis, subparallelo-subintertextis, filamentosis efformata, subtus autem gradatim in contextum pilei sphaerocystis intermixtum transeunte. Lamellis ochraceo-cremeis, anastomosis paucis transversalibus connexis, aequalibus vel subaequalibus, simplicibus, sublatis (4 mm. latis in statu sicco), admodum distantibus (30–35), usque ad 5 mm. distantibus ad marginem, adnexo-attenuatis vel subdecurrentibus; sporis in massa non visis; sporis 6.3–6.8 × 4.5–5.5 μ, ornamentatione 0.2–0.3 μ alta, typi VI, raro IV; basidiis gracilibus, 35–45 × 5–7 μ, tetrasporis; sterigmatibus 4.5–5 μ longis; cystidiis paucis, subbasidiomorphis, saepe breviter appendiculatis; cheilocystidiis saepe e tramate ortis, versiformibus, saepe e cellula late cylindracea basali ecrescentibus, aut e compluribus talibus cellulis catenulatis ecrescentibus, e.g. 23 × 8 μ, vel minoribus; subhymenio bene evoluto, ramuloso, c. 25 μ crasso; tramate lamellarum e sphaerocystis (e.g. 33 × 31 μ) et hyphis connectivis numerosis tenuitunicatis, nonnullis autem crasse

tunicatis (membrana usque ad 1.5 μ) consistente. Stipite concolori, basin versus acuminato-attenuato, sublevi, nudo, glabro vel subglabro, farcto, c. 25 × 7 mm. in siccis. Carne albida; odore saporeque ignotis. In terra. Tjibodas, Java, F. v. Höhnel (FH).

Observations. — This species is like *Russula archaea* Heim in appearance. The cuticle is much like that of *R. fistulosa* Heim form B, from which our species differs in spore ornamentation and other characters, e.g. the very distant lamellae. *R. archaea* has a similar cuticular layer, but is, at the same time, said to be glabrous. The spores of our species agree with those of *R. archaea*, and so do the cystidia, which are very scattered and inconspicuous. Our species differs mainly in the verruculose pileus (but the density of the warts on the disc is such that the surface appears almost smooth) and in the constantly 4-spored basidia and the thinner lamellae, which in *R. archaea* are often bifurcate or accompanied by lamellulae.

It seems to me that *Russula archaea* is for the most part quantitatively different from a few similar species, among them *R. Hoehnelii*, *R. Earlei*, and *R. fragilissima* Heim. At one time I would have regarded them as belonging in subsection Elephantinae, but it now appears that the subsection is not so natural as the other subsections used in Russula. In fact, the part of the Elephantinae in which the species named above belong should now rather be known as Archaeinae Heim, whereas the type species of the subsection (*R. mustelina* = *R. elephantina*), along with the subsection, is quite closely related to some groups of the Rigidae, rather than to the Compactae. In the subsection Elephantinae emend. belong *R. elephantina* Fr., *R. subalbidula* Murr., and probably *R. persobria* Kauffm. ex Sing. On the other hand, the species of the Archaeinae named above are somewhat intermediate between the subsection Delicinae of the Compactae and Fistulosinae of the Ingratae. They can be distinguished from one another by the following key:

A. Spores with mostly isolated punctation
  B. Pileus up to 50 mm.; tropical species
    C. Lamellae forked, intermixed, and, comparatively, very thick; pileus glabrous; basidia 2-spored and 4-spored
      Russula archaea Heim
    C. Lamellae mostly simple and equal; pileus warty; basidia all 4-spored ..... *Russula Hoehnelii* Sing.
  B. Pileus larger; American (temperate) species ..... *Russula Earlei* Peck
A. Spores with reticulating connecting lines between the warts
  Russula fragilissima Heim

Russula liberiensis Sing. sp. nov.

Pileo fuligineo-fusco, rimosello-granuloso e verruculis punctiformibus, centro leviore, margine extremo striato, demum infundibuliformi, c. 60 mm. lato; granulis e sphaerocystis accumulatis, saepe ovoideis, paucis in hyphas ellipsoideas vel cylindraceas elongatis, omnibus crasse tunicatis, constantibus; pigmento intracellulari dissolutoque et granuloso-globuloso ochraceo-brunneo manifesto; membranis 0.6–2 μ crassis, refringentibus. Lamellis albis, brunnescentibus fractu, sublinearibus, haud ventricosis, angustis, lamellulis perpaucis intermixtis, tenuibus, adnexis, confertissimis; sporis in cumulo haud visis, probabiliter albis vel albo-cremeis, sub microscopio 6.8–9.5 × 6–8.8 μ, distincte asymmetricis, subglobosis, plerumque 7–7.5 × 6–6.5 μ, ornamentatione 0.2–0.5 μ alta, cristulato-reticulata (typi I); basidiis c. 24 × 7 μ, tetrasporis; sterigmatibus 5–5.5 μ longis; cystidiis 32–53 × 4–10.5 μ, versiformibus, clavatis, fusoideis, etc., apice acutis vel rotundato-obtusis, intus granulosis vel corpusculis vermiformibus impletis; tramate sphaerocystis numerosis praedito. Stipite cremeo-albido, tactu brunneolo-albido, furfuraceo-granuloso, spongioso, solido, aequali, c. 55 × 14 mm.; granulis e corpusculis eis pilei similibus, sed magis elongatis, plerumque catenulatis efformatis; membris individualibus catenulae 5.5–13 μ crassis, membrana c. 0.7 μ crassa, intus subgranulosis. Carne alba, in pileo fragili, in stipite spongioso; odore terreo; sapore haud notato; sulphovanillinae actione haud mutata sed granulis externalibus nonnullis brunnescentibus. In terra humosa, verne. Nengbe, Liberia. G. W. Harley, 50.

Observations. — This species belongs in the subsection Fistulosinae Heim of the section Ingratae Quél. and, because of the thick-walled epicuticular bodies, is closely related to *Russula crassotunicata* Sing. from North America.

XIII. Three Species of Russula, sec. Decolorantes

Russula rubriceps (Kauffm.) Sing., Mycologia, 35 : 151. 1943

Russula decolorans var. *rubriceps* Kauffm., Rep. Mich. Acad., 13 : 215. 1911.

Pileus evenly red (bright *emetica*-red; "scarlet red" [R.], to "nopal red"), the center sometimes stained with pallid spots,

opaque, convex with depressed center, with smooth, later tuberculate-sulcate, subacute, later obtuse and even often rounded, margin, large (70–90 mm. in diameter), with glabrous to subglabrous cuticle that is separable in the outer third of the radius, and viscid in wet weather. Lamellae stramineous-ochraceous when mature, broad (about 12 mm.), frequently intermixed with some lamellulae, anastomosing with low veins, some forked or all simple, not ventricose, adnate, later separating from the stipe, subdistant to crowded, most frequently close; spore print between D (Crawshay) and E, nearer E, but more salmoneous. Stipe white, the apex often pink, almost constantly ventricose, or subventricose, subrugulose, firm, eventually somewhat fragile, 70–90 × 16–32 mm. Context white, reddening on injury, then becoming dark gray; red discoloration as well as subsequent gray one especially evident on stipe upon the slightest scratch. Odor of the fresh context none, later like that of cheese (Camembert); taste mild.

Spores 8–10 × 7–8.5 μ, yellowish, short-ellipsoid-subglobose, echinulate, ornamentation projecting about 1.3 μ, consisting of cylindric spines, which are usually isolated (type VI), but when observed under oil immersion lens can be seen to have extremely fine lines connecting some of the spines (IV, IIIb, IIb), rarely some of the spines fusing into each other to form short ridges (II–IV); basidia 30–39 × 10–10.8 μ, 4-spored; sterigmata 7 μ long; pseudocystidia 40–80 × 8–10.5 μ, fusoid or clavate, obtuse, entirely and evenly blue in sulphovanillin, rather infrequent or, more often, rather numerous; epicutis with a moderate number of well-developed pseudocystidioid dermatocystidia shaped like those of the hymenium, usually with a large blue body in the middle when seen in sulphovanillin.

Chemical characters. — Context turning red (quick and strong reaction) with formalin.

Habitat and distribution. — Under various trees (*Tsuga canadensis*, even in pure stands, but also in oak woods; according to Kauffman, under *Pinus strobus* and *Fagus grandifolia*) in not too dry places in hilly woods, as well as in low places, usually gregarious, from June till fall. From New England west to Michigan; and south to Virginia.

Observations. — *Russula rubriceps* is common in Massachusetts and can easily be distinguished from *R. rubescens* Beardsl. by its

bright red pileus and larger size. Under ideal circumstances *R. rubescens, R. rubriceps, R. vinosa,* and *R. seperina* all turn red before staining gray or black when scratched, and this character is of no value in distinguishing these species.

Russula vinosa Lindb. ssp. **occidentalis** Sing. ssp. nov.

A subspecie typica differt magnitudine majore, colore magis ardesiaco-violaceo vel viridello in pileo, sporis majoribus spinis longioribus echinatis. America Borealis occidentalis.

Since I have already given a rather complete description based exclusively on this Western form, or rather race (*Bull. Soc. Myc. Fr.*, 55 : 257. 1939), I have only to add some supplementary notes here.

Pileus not only "Prussian red" (R.) or "haematite red," but also frequently "deep purplish vinaceous," and mixed with "vetiver green" or, later, "tea-green," margin usually remaining "dull lavender," but sometimes almost entirely olivaceous with only a faint lilac tinge,[2] center sometimes almost black. Spore print near "Naples yellow," between D (Crawshay), F, and E in a good print, generally nearer to E. Spores with ornamentation of type VI or, just as frequently, type IV, warts (1.0)1.5 (2.0) μ long, spores always of size indicated by me (9–14 × 8.5–12 μ), never smaller.

Distribution. — Apparently a geographic race confined to the states along the Pacific coast and the Rocky Mountains, U. S. A., having been found in Idaho (Kauffman), Oregon (A. H. Smith), and probably Washington (Murrill; see Burlingham, *Mycologia*, 5 : 309. 1913).

Russula pseudolepida Sing., Bull. Soc. Myc. Fr., 55 : 251. 1939

This very variable species has already been described from material collected by C. H. Kauffman in Maryland and was tentatively put in the section Rigidae, subsection Lepidinae. Abundant fresh material, collected in New England, enables me now to publish an emended description that will prove that *Russula pseudolepida,* in spite of its external appearance, belongs in the section Decolorantes,

[2] These colors are taken from notes by A. H. Smith on material from Oregon determined by R. Singer (Mich., FH).

subsection Xerampelinae. The chemical characters indicated here would hardly be expected, and Heim's contention that the Xerampelinae and the Lepidinae are closely related seems to become more likely again.

Pileus in all colors occurring in *Russula lepida*, but also in some special colors or color combinations, such as "troubadour" Maerz and Paul), "Red Cross," "Afghan red," "checkerberry," "old red," or an even darker red in places, or one of these vivid reds or "jasper red" (R.), or "Pompeian red" mixed with yellow blotches "antimony-yellow" to between "maize-yellow" and "buff yellow"), both colors bleaching in age, the red becoming "light grayish vinaceous" to "hydrangea red," the yellow becoming "cream-buff" to "chamois," sometimes also with white spots, these eventually growing larger and the reddish parts disappearing more and more, not infrequently, also, rather pale or yellow from the beginning (much like the final stage of the mottled bright-red–bright-yellow form), with only a little pink in the middle or with the reddish color blended with the yellow so as to seem "zinc-orange," smooth, usually very opaque when dry, subglabrous to subvelutinous, frequently subpustulose-subgranular in the very center, the cuticle separable, with some difficulty, part way from the margin, or in the more fragile forms more easily separable for up to two thirds of the length of the radius, with the margin smooth and rounded-obtuse, convex at first, then depressed in the center, 50–120 mm. broad. Lamellae white when young, but turning a very pale creamy ochraceous in age and darker when dried, sometimes whitish pruinate from the spores, with numerous low anastomoses, equal or subequal, medium broad (6–8 mm. in an average specimen), subclose to crowded, simple or with a few forked ones among them, variably adnexed, often somewhat sinuate, emarginate, adnate, or subfree; spore print B (Crawshay). Stipe white, but in some of the uniformly bright-red specimens partly pinkish red (near color shown in pl. I, 1–2, of Maerz and Paul, or deeper), but more frequently without any reddish tint, glabrous, subrugulose, subequal to equal, or tapering downward, more rarely tapering upward, varying from medium or short in the firmer specimens to more elongate in the paler, fragile specimens, stuffed in the latter, solid in the former, 35–80 × 12–26 mm. Context white, firm or, more rarely, fragile, especially in the paler, slender forms, unchanging or almost so, rarely becoming

very slightly sordid, never staining distinctly yellowish or brownish when wounded or in age or on drying; mild (i.e. not acrid), and at the same time more or less bitterish to distinctly bitter; usually inodorous, but developing a sweetish odor (like that of *R. emetica*) when dried, or an odor of chocolate or benzaldehyde.

Spores 8–11 (11.5) × 6.8–9 (9.2) μ, strongly echinulate, hyaline, asymmetric, short-ellipsoid-subglobose, ornamentation of types IIIa, IIIb, IV (one of these may be entirely absent in an individual print), often with some spines having rather thick connecting lines (II, II–IIIa, II–IIIb, II–IV), or with rather isolated spines (V, VI), but these always in the minority, projecting (0.4) 0.6–0.9 μ, sometimes in a print a number of spores having ornamentation projecting up to 1.3 μ; basidia 28–44 × 9.5–12 μ, 4-spored, occasionally very few 2-spored; sterigmata 6–10.5 μ long; cystidia on edges and sides of lamellae, not bluing in sulphovanillin, empty or granulose inside, the granulosity usually confined to the upper portion of the cystidia, 62–100 × 6.5–13.2 μ, more numerous at the edges, there often narrower and long-appendiculate or sometimes capitate, otherwise similar to those on the sides of the lamellae, which are versiform (cylindric, fusoid, subulate, short-appendiculate or nonappendiculate, acute or obtuse); cheilocystidia nonpseudocystidioid, scattered to numerous, cylindric-filiform or subulate, more rarely fusoid, refringent, sometimes branching, 2.5–7 μ broad, of variable length, acute, more rarely obtuse; edge of lamellae simultaneously subheteromorphous (because of denser cystidia) and heteromorphous (because of the cheilocystidia); epicutis of pileus without pseudocystidioid dermatocystidia but with cheilocystidioid hairs or similar hyphae ends which have walls 0.5–1.5 μ in diameter, smooth and hyaline; aside from these, more or less numerous primordial hyphae with colorless or yellow incrustations usually present, their terminal members often fusoid or clavate, 4–5.5 (7.5) μ in diameter; hyphae of the subcutis thin-walled, not erect, filamentous, hyaline or with easily dissolving pigment, clampless.

Chemical characters. — $FeSO_4$ reaction on flesh, pale sordid gray, slowly becoming pale to dark olive gray, more distinctly olive in the interior of the adult stipe, more orange buff in the lamellae. Aniline, after about ten minutes, from light sordid red to distinctly positive, as in *Russula xerampelina*. Formalin, in interior of stipe, rapidly pale brown, otherwise almost negative, or negative. Phenol normal

(chocolate color). Methylparamidophenol, slowly to rapidly strongly positive (deep violet, eventually black). NH_4OH everywhere negative. KOH and HNO_3 on pileus negative. Sulphovanillin on dried flesh and surface of stipe exactly as in *R. Zvarae* ("Tommy red," "bonfire," soon "Red Cross," or deeper carmine purple on surface, "Russian calf" in interior of stipe). Chlorovanillin not deeper than "baby-rose," "candy-pink," "coral," "confetti," "sunglow," pallescent after a while.[3]

Habitat and distribution. — Consistently in mixed woods, usually near oak mingled with *Tsuga canadensis* or *Betula sp.* or both; generally in small to large groups; fruiting from July until October, most frequently (commonly in some regions) in August and September. From New England south to Virginia; western limits unknown.

Material studied. — New Hampshire: Alton Bay, D. H. Linder, 1944 (FH), two collections. Massachusetts: Harvard, Harrie Dadmun and R. Singer, 1945 (FH); Lynnfield, R. Singer, 1943 (FH); Wakefield, R. Singer, 1943 (FH). Pennsylvania: Gretna Park, C. H. Kauffman (as *Russula borealis* f. *gretnana*), cotype (Mich.). Maryland: Tacoma Park, C. H. Kauffman (as *R.* aff. *lepida*), type (Mich.). Virginia: Mountain Lake, R. Singer, 1946 (FH).

Observations. — This species is rather frequent in its area, and is generally determined as *Russula lepida*, from which it differs abundantly in the lack of the dermatopseudocystidia on the pileus, the larger, more strongly ornamented, and, on the average, more reticulated spores, the reaction with $FeSO_4$ and aniline, and other less important characters. It also differs from all other species of the Lepidinae in the reaction with $FeSO_4$ and aniline. It differs from *R. xerampelina* in the absence of discoloration after bruising and in the lack of a trimethylaminous odor, also in the lack of any bluing bodies in sulphovanillin and in the bitterish taste. It differs from *R. oreina* Sing. in the habitat, the bitter taste, and the lack of brownish discoloration and of dermatopseudocystidia on the pileus, as well as in the colors. *R. pseudolepida* and *R. oreina* are characterized by the same chemical features as the other Xerampelinae and by the absence of the odor which occurs in *R. xerampelina* and *R. compacta*.

[3] *R. rosea* matches pl. 1, L6, then pl. 2, L6, then pl. 3, L6, then pl. 4, L6 (Maerz and Paul) in the interior as well as on the cortex.

XIV. Redescription of Russula americana

Russula americana (Sing.) Sing., Bull. Soc. Myc. Fr., 55: 264. 1939

Russula rosacea var. *americana* Sing., Bull. Soc. Myc. Fr., 54: 146. 1938.

Pileus uniformly bright red (about "nopal red" [R.]), very viscid but drying rapidly, glabrous, smooth to rugulose, strongly shining to opaque depending on the degree of viscidity on drying, moderately thick, broadly convex, the center applanate or becoming depressed, with margin eventually slightly tuberculate-striate but never rounded, pellicle separable with difficulty part way from margin, wounds reddish or becoming so. 30)50–60 mm. broad. Lamellae white, becoming dull cream-color, close or subdistant, more often subdistant (in fully mature specimens), adnate or subdecurrent, more often subdecurrent (in fully mature specimens), anastomosing or deeply forked, a few conspicuously forked near the stipe, moderately broad, broadest in the marginal third; spore print D (Crawshay) in intensity, but tone near "Naples yellow" (R.), "light buff," or "cartridge-buff." Stipe "geranium-pink," usually uniformly so up to the lamellae, though occasionally spotty, subrugulose, at least when mature, at times subpruinose at the apex, or almost furfuraceous, otherwise glabrous, solid or stuffed, becoming hollow, 40–60 × 10–15 mm., subequal or thicker at the apex. Context white, unchanging, but reddish under the cuticle and, often, along the surface of the stipe and in wounds, rather fragile (more so than *Russula rosacea*); taste more or less rapidly intensely acrid, or at least with a distinct burning aftertaste; odor not remarkable.

Spores (8.5)9–11(11.5) × (7)8.2–9.5(10.8) μ, yellowish hyaline, densely warty, ornamentation of type IV, V, or VI, more rarely IIIb, projecting 0.6–1.0 μ, more rarely a number of neighboring warts combining into a short ridge (IV–II); basidia 37–42 × 9.5–10.2 μ, 4-spored, pseudocystidia 60–88 × 6.8–14.5 μ, usually fusiform, the broadest part in the middle or, more often, in the upper third, with banded contents in almost its entire length, turning blue in sulphovanillin, the apex usually attenuate-rounded, rarely with button-like appendage, or with a crystalline hood, very numerous; edge of lamellae homomorphous; epicutis of pileus with numerous versiform dermatopseudocystidia (66–100 × 2–8 μ).

Chemical characters. — Chemical reactions not studied.

Habitat and distribution. — Under conifers such as Abies and Tsuga, on the ground; fruiting in September and October. Western U. S. A. Washington: Noisy Creek, Baker Lake, A. H. Smith, 16672 (FH), also collected by C. H. Kauffman (as *Russula rosacea* Fr.) (Mich., LE). Oregon: South Fork of Salmon River, Mount Hood, Gruber and Smith, 19151 (Mich., FH), 19505 (Mich.); swamp at Bear Springs, Mount Hood, A. H. Smith, 19221 (Mich., FH). California: A collection from the San Francisco Bay region, brought in by a member of the California Mycological Society in 1932 (?) and determined by V. Mentzer as *R. sanguinea* (Bull. ex Fr.) Fr., which grew among needles on the ground, is probably *R. americana* (FH).

Observations. — This beautiful species, recently re-collected and sent to me by A. H. Smith, is closely related to *Russula rosacea* Fr., from which it differs in the larger spores and the more fragile flesh and in the habitat. It also differs from *R. rhodopoda* Zvára in the different habitat, larger and less reticulated spores, and deeper spore-print color. *R. rubicunda* can be distinguished by its less strongly and less constantly red stipe and its habitat under hardwoods.

TRICHOLOMATACEAE

XV. Additional Data on Catathelasma and Armillaria

Catathelasma ventricosum (Peck) Sing., Rev. d. Mycol., 5 : 9. 1940

Armillaria ventricosa Peck, Bull. Torr. Bot. Club, 23 : 414. 1896.

When studying the European *Catathelasma imperiale* (Fr.) Sing., I found that it had a bilateral trama (see *Ann. Myc.*, 34 : 330. 1936); later I found that Biannularia G. Beck was a synonym of Catathelasma Lovej., which also includes the American species *C. ventricosum*. Mature herbarium specimens of the latter showed regular trama (see *Rev. d. Mycol., loc. cit.*). Fresh material sent to me from Maine in 1945 shows, however, strongly bilateral trama in young specimens, reminding one of the boletes; yet the strongly divergent lateral stratum as well as the mediostratum is pallid-hyaline, and the mediostratum is not pigmented.

The spores are (8) 10–18.5 × 4.2–5.5 μ, amyloid, smooth, mostly

10–13.5 × 4.8 μ; a print was not obtained. The basidia are 4-spored, enormously long (50–68 × 7.5–8 μ). The subhymenium is ramose but its elements are very short; all hyphae are nonamyloid, with clamp connections, distant septa (except the subhymenium), and thin walls. I have not seen any cystidia of any kind.

KOH, NH_4OH, formalin, and phenolaniline are all negative on the flesh as well as on the surface of the pileus. The taste and odor are the same as in fresh *Catathelasma imperiale*. Only the colors are different in these species. The pileus is ocher-pallid or brownish white with grayish patches (instead of much darker as in *C. imperiale*) and the annulate partial veil is ocher-pallid, not blackish fibrillose. The lamellae become pale grayish ochraceous in age, and they tend to separate from the flesh.

This is a gigantic fungus, at first glance reminding one of *Russula delica*. It grows in northern coniferous woods. There is material preserved in alcohol from Castine, Maine, in the Farlow Herbarium, as well as dried materials from Pemaquid, Maine, and other localities. Only one specimen was determined as *Armillaria Laschii* Fr. by Farlow. The latter is undoubtedly, among all European species, the one that comes closest to *Catathelasma ventricosum* in appearance, but it is little known in Europe.

Armillaria luteovirens (Alb. & Schw. ex Fr.) Sacc., Syll., 5 : 75. 1887

This species has not been studied, thus far, very thoroughly. Since it belongs, however, to a unique type of some taxonomic interest, we shall add some hitherto neglected data which were obtained from material collected near Budapest, Hungary, by Moesz, in October, 1927 (FH).

Lamellulae abruptly rounded as in some species of Leucopaxillus and Amanita; trama of the lamellae consisting of a mediostratum flanked by a well-developed hymenopodium; the mediostratum subregular with interwoven broad (up to 12.5 μ), rather short (comparatively) hyphae; the hymenopodium composed of parallel thinner (3.5–5.5 μ) hyphae, not divergent in the stage the specimens had reached; subhymenium consisting of chains of very short hyphae, subcellular, its elements about 4.5 μ in diameter; no cystidia; basidia 27–34 × 6–7.8 μ; spores much like spores of Amanita,

smooth, short-ellipsoid, thin-walled, asymmetric, with no oil droplets or with from one to several oil droplets, without suprahilar depression, amyloid, not seen in print but perfectly hyaline, 6–8 × 4–5.5 μ; velar scales of the pileus consisting of hyphae which are almost radiately arranged but often more or less interwoven, some very short, smooth, hyaline, thin-walled, much like those of the mediostratum; cuticle proper of the pileus consisting of subparallel, thin-walled, hyaline hyphae, reminding one of the structure of the hymenopodium, these hyphae about 2.5 μ thick; all hyphae with clamp connections and nonamyloid.

Observations. — This species is generically different not only from Tricholoma and Armillariella, but also from genera more closely related to it, like Leucopaxillus. It has never been reported from America, but some other species have been described in this country which, according to their characters, may eventually enter the genus Armillaria as emended by me.

XVI. Redescription of *Collybia ignobilis*

Collybia vulgaris Sing. nom. nov.

Collybia ignobilis Karst. sensu auctorum Americanorum, non Karsten.
Gymnopilus ignobilis Murr., North American Flora, 9 (5) : 364. 1916.

Pileus grayish ochraceous, dirty brownish gray, horn-gray, "tilleul buff" (R.), even "vinaceous buff," hygrophanous, innately radiately fibrillose to almost homogeneous, paler when dry, short-striate on the margin when wet, or persistently astriate, glabrous, smooth, naked, nonviscid, convex with mostly umbilicate, or at least flatly depressed, center, 12–26 mm. broad. Lamellae pale creamy gray, almost pallid, broad, slightly and partially ventricose or applanate, rounded-adnexed, or adnate-subdecurrent, irregularly decurrent in very young specimens, somewhat eroded, later often wavy at the edge, medium distant to distant, with concolorous edge; spore print pure white. Stipe paler than the pileus, subconcolorous with the lamellae, often nearly pallid-whitish, narrowly tubulose, longitudinally innately fibrillose-silky when young, later quite glabrous and smooth, equal or subequal, 20–40 × 1.5–5 μ; mycelium white. Context concolorous with the surface, at least in the peripheric parts of the pileus and stipe, otherwise white or whitish; odor slight, farinaceous; taste farinaceous (and sometimes bitterish), slight.

Spores 6.5–8.2 × 4.8–5.3 μ, mostly about 7.6 × 5.2 μ, smooth, thin-walled, nonamyloid, sometimes with one oil droplet or without oil droplets, or frequently with numerous small oil droplets, many of them crowded near the wall and making it appear to be rough (but this is a refraction effect; the wall is never rough in Melzer's reagent, in which the oil drops disappear), almost ellipsoid; basidia 24–35.7 × 7.5–8.5 μ, 4-spored, without carminophilous granulation; no cystidia or cheilocystidia; gill trama regular, consisting of parallel, filamentous hyphae; hyphae of cuticle radially arranged, filamentous, incrusted with a melleous pigment, all hyphae with clamp connections, thin-walled, nonamyloid.

Chemical characters. — $FeSO_4$ reaction slowly and unequally gray, eventually grayish black.

Habitat and distribution. — In various habitats, e.g. on the ground in woods, under trees, on lawns and the like, on dry hills among mosses, and on wet ground as well, most frequently in frondose (but also in coniferous) woods among Polytricha; gregarious; fruiting from June until October. Extremely common in Massachusetts, reported from New York and Illinois; has not been noticed by me in northern Europe. (*Collybia ignobilis* Karst. is certainly not this plant!)

Observations. — *Collybia vulgaris* belongs in an interesting section of Collybia, one which (because of its colors, odor, and the variable attachment of the lamellae) was first regarded as belonging to Clitocybe rather than to Collybia. The collybioid habit, however, and the incrusting pigment are, among other characters, strong arguments in favor of Collybia. I therefore propose the following section:

Farinolentes Sing. sec. nov.

Hyphae pigmento incrustatae, sordido, subgriseo, in pileo radialiter parallele dispositae. Stipes glaber. Caro haud revivescens. Sporae in massa albae. Species typica: *Collybia vulgaris* Sing.

Other species that probably belong here are *Collybia clusilis* (Fr.) Gill. sensu Konr. & Maubl. (which differs in having larger spores) and perhaps what Lange calls *Clitocybe pachyphylla* Fr., unless it is a synonym of *Collybia clusilis*. This whole section has a characteristic reaction with $FeSO_4$ which reminds one of the genus Laccaria.

XVII. A New Species of Omphalina in the Alpine Zone of the White Mountains

Omphalina oreades Sing. sp. nov.

Pileo spadiceo-fusco vel umbrino, hygrophano, pallide umbrino in statu sicco, margine dilutiore, pellucide striato in humidis, neque viscido neque vestito, at levi glabroque, convexo atque umbilicato vel exumbonato vel papillato, dein centro depresso, 3–10 mm. lato; cuticula paulum differentiata, ex hyphis filamentosis, repentibus vel vix ascendentibus, subirregulariter dispositis, interdum breviter cylindraceis vel claviformibus, pigmento fusco epimembranali incrustatis et ex ea re asperulatis efformata. Lamellis cremeo-griseolis vel flavido-umbrinellis, adnato-decurrentibus vel decurrentibus, arcuatis vel applanato-subhorizonalibus, maturis saepius profunde decurrentibus subarcuatisque, moderate latis (1–2 mm.) vel latis (2–2.5 mm.), distantibus vel eximie distantibus; sporis 6.8–8.2 × 3–7 μ, levibus, haud amyloideis, guttula centrali globosula minore saepe praeditis, tenuitunicatis, bis opposite curvatis (tildiformibus) vel parte hilari modo incurvata latus interius versus et ceterum ellipsoidalibus, hyalinis; basidiis 22-24 × 6.5-6.8 μ, tetrasporis; cystidiis nullis; ad marginem pilei interdum cheilocystidia sparsa, parvula, inconspicua (16–27 × 5–6.5 μ), ampullacea vel subcylindracea occurrunt; tramate ex hyphis cylindraceis vel allantoideis vel filiformibus irregulariter dispositis efformato, intermixto subregulari, inamyloideo. Stipite pileo concolori vel magis griseolo pallidioreque, pruinoso, glabrescente, aequali, curvato vel recto, farcto, 10–12 × 1–1.5 mm.; velo nullo. Carne subconcolori superficiebus, inodora, miti; hyphis fibulis destitutis. In terra arenosa vel prope Polytricha ad fissuras rupestres solitario vel gregatim, Julio mense. In zona alpino-tundrica supra et ad limitem arborum in Mount Washington, White Mountains, New Hampshire, U. S. A.

Observations. — This species was collected by me in 1945 on two occasions. It is the only endemic species of the alpine zone of the White Mountains known thus far. The other species are all such as can stand the extreme climatic conditions of the Presidential Range, but are neither arctic nor alpine in distribution, belonging to the surrounding temperate-forest flora, which is holarctic-boreal or North American-Siberian or North American-boreal. The farther one descends into the valleys, the higher becomes the percentage

of American southern-temperate to subtropical species (such as *Amanita flavoconia*, *Russula compacta*, *Boletus rubellus* ssp. *bicolor*, and similar representatives of the moisture-loving flora of regions that are rather warm, at least in summer; these species abound in New England in the summer months, but are replaced by more boreal species in the fall). The only other species seen at as high an elevation on Mount Washington (5,200–6,260 feet) as *Omphalina oreades* were *Laccaria laccata* and *Deconica atrorufa*.

Omphalina oreades differs from other species of the section Genuinae Romagn. (i.e. the species without clamp connections, without differentiated cuticle, and without cheilocystidia or dermatocystidia, with white spore deposits, without carminophilous granulosity in the basidia, with nonamyloid smooth spores, with, often, incrusting pigment) in having a very peculiar kind of spore. *O. umbellifera* var. *abiegna* (B. & Br.), which is not uncommon in the subalpine zone of Mount Washington, differs in color, habitat, and spore shape; *O. philonotis* (Lasch) Quél., another circumboreal species, differs in size, color, habitat, and spore shape. Most of the remaining species of Omphalia (Fr.) Quél. sensu lato have clamp connections and belong either to the section Fibulatae Romagn. (*O. griseopallida*, *O. rustica*, *O. pyxidata*, and so on), or to Clitocybe (*C. hydrogramma*, *C. umbilicata*, and so on), or to Mycena (*M. swanetica*), or to Marasmiellus (*M. tricolor*, *M. fibula*, *M. crispulus*, *M. gracilis*, and so on), or to Xeromphalina (*O. campanella*), or to Fayodia (*F. bisphaerigera*, *F. maura*), or to other genera. Omphalina Quél. emend. Singer is closest to Armillariella.

XVIII. Tropical Species of Calocybe

Calocybe cyanella Sing. sp. nov.

Pileo caeruleo ("dusky violet-blue" [R.], "nigrosin-blue," "dark madder-blue"), appresse subtomentoso, margine initio incurvo, levi, plano vel subdepresso in centro, c. 30 mm. lato; epicute ex hyphis subparallelo-subintertextis, filamentosis, repentibus, raro singulis ullis ascendentibus, sed locis quibusdam dispersis abbreviatis et in catenulas sphaerocystarum parvularum transeuntibus efformata; sphaerocystis illis 4–7 μ in diametro; hypodermio ex hyphis crassioribus, magis intertextis consistente et in carnem pilei transeunte, a qua pigmenti praesentia tantum differt; pigmento incrustante

membranas hyalinas sed partim in succo cellulari dissoluto, solubili in ammoniaco (NH_4OH) et colorante alias hyphas in violaceum vel caeruleum. Lamellis albis, satis angustis, saepe sublaceratis, confertissimis, emarginato-rotundatis, attingentibus, an demum subdecurrentibus (?), lamellulis rotundatis neque attenuatis, marginem sterilem angustum relinquentibus ibique attenuatis; sporis in cumulo albis, sub microscopio hyalinis, nonamyloideis nec pseudoamyloideis, tenuitunicatis, levibus, ellipsoidalibus, guttula conspicua carentibus, $4–5 \times 2.5–3.3$ μ; basidiis clavatis, constanter tetrasporis, granulatione carminophila impletis distincta, $18.5–22.5 \times 4.8–5.5$ μ; cystidiis cheilocystidiisque conspicuis nullis, at aciebus nihilominus paene subheteromorphis e cheilocystidiis haud manifestis, centro ventricosis vel attenuatis, versiformibus, hyalinis, 18×4.5 μ; tramate lamellarum regulari, hyalino, haud amyloideo, ex hyphis tenuibus, subparallelis, magis intertextis, ubi contextum pilei et aciem approximant, consistente. Stipite caeruleo ("pale Windsor blue" [R.]) ad apicem, albo ad basin, glabro, aequali vel ad basin subattenuato, tomento basali albo, 30×3 mm. Carne alba, carnosa, mediocriter crassa; sapore farinaceo et minime amarulo; odore farinaceo; hyphis omnibus fibuligeris, in carne fortiter intertextis et irregulariter dispositis, nonnullis membrana paulum incrassata instructis. In terra in dumetis tropicalibus solitario, Septembri mense. Florida, U. S. A.

Chemical characters. — Surface of the pileus unchanging with NH_4OH, aniline, and formalin, becoming purer and more dilutely blue with KOH; flesh not reacting with these reagents, but becoming slowly and not intensely positive (lilac) with methylparamidophenol, eventually turning almost black.

Type specimen. — Collected by me at Matheson Hammock, near Miami, Dade County, Florida, F–734 (FH).

Observations. — The genus Calocybe Kühn. is not uncommon in the American tropics. In Rick's collections from Brazil, sent to Farlow Herbarium without determinations, there are at least two more species, and Murrill described a *Collybia atroviolacea* (*Gymnopus atroviolaceus* Murr.) which belongs in Calocybe. Murrill's species, according to my study of the type (FLAS), is extremely similar to, and probably identical with, *Calocybe ionides* (Bull. ex Fr.) Kühner, but both of the Brazilian species are new.

Calocybe rubra Rick, in herb., sp. nov.

Pileo carneo-rubro, centro obscuriore, levi, sphaerocystis aegre visibilibus in superficie. Lamellis adnexis, polymacriis, angustis, confertissimis, concoloribus in siccis; sporis in cumulo haud visis, sub microscopio hyalinis, levibus, haud amyloideis nec pseudoamyloideis, ellipsoidalibus, tenuitunicatis, 3.2–3.5 × 2–2.5 μ; basidiis clavatis, tetrasporis, granulatione carminophila impletis distincta, 13–17.5 × 4.2–4.6 μ; cheilocystidiis versiformibus, in typo sparsis; tramate regulari, inamyloideo. Stipite concolori, albofarinaceo, 3 mm. crasso. Carne moderate crassa; hyphis omnibus fibuligeris. In ramentis arborum frondosarum. J. Rick, 585, 1928 (FH).

Observations. — Rick regarded this as a Collybia, but never published it. Its characters are sufficient to distinguish it, although better material, with more notes, is needed for certain data which are still lacking.

Calocybe cyanea Sing. sp. nov.

Pileo violaceo vel cyaneo vel coriaceo, saepe adiposo, centro atroviolaceo vel subatro, in siccis plumbeo-griseo vel fusco-ardesiaco (in typo "blackish brown [2]" Ridgwayi in centro et "deep brownish drab" vel "benzo brown" ad marginem, in collectione altera unicolori "Hathi gray" vel "deep neutral gray"), glabro, levi vel obiter rugoso, margine interdum undulato, e convexo expanso applanato, carnosulo, c. 30 mm. lato; epithelio epicuticulari bene evoluto, e sphaerocystis numerosis distinctissimis, 5–25 × 5–17.5 μ consistente. Lamellis albis, in siccis iam albidis, linearibus vel sublinearibus, confertissimis, acie saepe erosis, adnexis; sporis hyalinis, breviter ellipsoidalibus, levibus, tenuitunicatis, minusculis, 3.2–3.5 × 2.3–3.2 μ; basidiis tetrasporis, 14–20 × 4.5–5 μ, granulatione carminophila impletis; tramate regulari. Stipite pileo concolori, sursum et deorsum albido, striatulo, subaequali, subfirmo, 30–35 × 3–4 mm. Carne molli vel sublenta; odore saporeque haud notatis; hyphis fibuligeris; neque hyphis nec sporis amyloideis. In ramulis stipitibusque delapsis in silvis. Porto Novo, prov. Sta Catharina, Brasilia. J. Rick, 1928 (FH).

Observations. — This species differs from *Calocybe rubra* in the color of the pileus, in the fact that the lamellae remain white when dried and perhaps, also, in the structure of the cuticle. The type

is the violet form with the dark center, but in view of the identity of the microscopical characters, I regard another of Rick's collections, which is now evenly gray, as a variety. This variety cannot at present be described under a separate name since the notes on the fresh fungus are insufficient. *C. cyanea* differs from *C. cyanella* in the structure of the epicutis and in having smaller spores.

The identity of Rick's *Clitocybe cyanea* could not with certainty be established, but considering the colors of the plant he describes, its occurrence in Brazil, and the variability in the form of attachment of the lamellae in Calocybe, it might be *Calocybe cyanea*. The spores would have been indicated incorrectly by Rick, if my suspicion regarding the identity of these species is justified, and the caespitose habit would be the only distinguishing character remaining between them. I have purposely chosen the same specific epithet in order to avoid a change if they should later prove identical.

XIX. A New African Species of Hydropus

Hydropus (Kühner) Sing.[4]

Pileo cheilocystidiis latis, interdum sphaerocystoideis erectis, tenuitunicatis, demum ruptis tecto; pigmento tristi vel nullo; hyphis inamyloideis, fibuligeris; cheilocystidiis versiformibus, distinctis; sporis albis, breviter ellipsoideis vel ellipsoideis, levibus, amyloideis, in cumulo albis; lamellis variabiliter adnatis vel plus minusve decurrentibus. Habitu suo inter Omphalinas et Collybias intermedium genus. In lignis et in humo lignoso in zonis temperatis et tropicalibus. Typus generis: *Hydropus fuliginarius* (Batsch ex Fr.) Sing., *Mycologia,* 35 : 160. 1943.

Hydropus africanus Sing. sp. nov.

Pileo fumoso ("smoke-gray" Ridgwayi), griseo-olivaceo-striato, breviter subsulcato, tomento squamisque destituto sed probabiliter pruinoso in statu vegeto, convexo vel subapplanato, in siccis umbilicato, 20–25 mm. lato; epicute e dermatocystidiis numerosis, erectis, subhyalinis, caducis, e.g. 30×11 μ formata; hypodermio crasso,

[4] The section Hydropus Kühn. of Mycena has been taken over by me under a new status, that is, as a genus (*Mycologia,* 35 : 160. 1943; *Lloydia,* 5 : 129. 1942). Since Kühner has not given a Latin description of his new group, I supply it here.

brunneo-fusco, ex hyphis cylindrico-filamentosis repentibus efformato. Lamellis pallidioribus, subalbidulis, late adnatis vel subdecurrentibus, latissimis et saepe subventricosis, ad basin suam venose anastomosantibus, polydymis; sporis in cumulo albis, sub microscopio hyalinis, asymmetricis, globulosis vel subglobulosis, tenuitunicatis, levibus, membrana simplici, leniter sed distincte amyloidea instructis, 6–7.7 × 5–6.3 μ; basidiis granulatione carminophila destitutis, tetrasporis, c. 30 × 7 μ; cystidiis nullis; cheilocystidiis versiformibus, e.g. ampullaceis vel clavatis vel bis ventricosis, etc., 20–33 × 3.5–7 μ; tramate subregulari, e cellulis elongatis, voluminosis, inamyloideis consistente. Stipite pileo concolori, subpruinato, tomento basali subdestituto, arrhizo, subaequali, subcartilagineo, tubuloso, 22–30 × 1–2 mm. in siccis, pruina e dermatocystidiis eis pilei analogis sed saepe latioribus formata; hypodermio stipitis ex hyphis subcrasse tunicatis, parallelis, longitudinaliter dispositis consistente; hyphis omnibus fibuligeris. In lignis putridis. Firestone No. 3, Du River, Liberia, Africa, July 27, 1926. D. H. Linder, 130 (FH).

XX. Notes on Some Species Intermediate between Marasmiellus and Marasmius

Marasmiellus tricolor (Alb. & Schw. ex Fr.) Sing. comb. nov. (*Agricus tricolor* A. & S. ex Fr., Syst. Myc., 1 : 166. 1821); forma **americana** forma nov.

A forma typica lamellis tarde leniterque lutescentibus differt. In viis silvestribus gregatim aestate, Arlington, Massachusetts, U. S. A. R. Singer (FH).

Pileus pure white, later whitish, nonviscid, nonhygrophanous, subsulcate, convex-umbilicate, sometimes the margin eventually uplifted, always sulcate and crenate in age, sometimes with a tiny papilla in the umbilicus, the umbilicus eventually becoming slightly alutaceous, slightly adpressedly subfibrillose at first, later perfectly glabrous but unpolished, 5–12 mm. broad. Lamellae white, in many older specimens still whitish, in others becoming light orange or at least with an indistinct orange hue, distant, simple, entire, medium to rather broad, adnate-subdecurrent and subhorizontal, later decurrent and descendent; spore print white. Stipe white at

the apex, later becoming gray at the base, sometimes almost blackish below, opaque, subfibrillose to pruinate-subfibrillose, usually rather short, 0.5–1 mm. thick. Context white, tough in the stipe, elastic-soft but not fragile in the pileus, perfectly inodorous.

Spores 10–11.5 × 4.8–5 μ, hyaline, thin-walled, nonamyloid, fusoid-ellipsoid, with a globose central oil droplet, smooth; basidia 35–42 × 7–8 μ, 4-spored; basidioles cystidiform, fusoid; pseudoparaphyses with large vacuoles, occasionally cystidiform, but real cystidia and well-differentiated cheilocystidia absent; epicuticular covering of pileus and stipe of the Rameales structure (echinate irregular bodies: "diverticulate," but not in palisade or forming an epithelium); all hyphae with clamp connections, nonamyloid.

Observations. — I have not studied the type, but, according to the description, I expect that *Marasmius vialis* Peck is the same form. Both grow along the forest paths on bare soil in summer, both are met with in the northeastern United States. There is not the slightest doubt that our form is conspecific with what is usually called *M. tricolor* or *Omphalia tricolor* in Europe. The spores are about the same size as those described by A. Ricken for *O. tricolor*, slightly smaller than those described by R. Kühner for his *M. tricolor* var. *sciodes*. They are much smaller than those in the closely related species **Marasmiellus caespitosus** (Pat.) Sing. comb. nov. (*Clitocybe caespitosa* Pat.) of North Africa, the type of which I have studied. Although Patouillard himself indicates that the spores of his species are much smaller, they are, when mature, 12.5–19 × 5–6.5 μ, mostly 14–16.5 μ long, and the cystidia are lacking; the irregular nodulose and dendroid-branched hyphae of the epicutis of the pileus and stipe are nearly the same in *M. tricolor* and *M. caespitosus*. I have not personally studied specimens of *M. Trabutii* Mre. (1909), but it seems to me that there is very little to distinguish this species from *M. caespitosus* (Pat.) Sing. The variety with smaller spores later described by Maire is a counterpart of the small-spored form of *H. tricolor* described above.

According to Kühner's classification of Marasmius, these species would enter the section Rameales Kühn. In view of the transitional character of certain tropical species such as *Marasmiellus semiustus* (Berk. & Curt.) Sing. and of certain European (*M. candidus* (Bolt ex Fr.) Sing.) and Asiatic (*M. pseudoconidiophorus*) species between Marasmius, Rameales, and Marasmiellus (= Hemimycena) I pre-

fer to transfer the section Rameales to the genus Marasmiellus, including the following species: **M. ramealis** (Bull. ex Fr.) Sing. comb. nov. (*M. ramealis* (Bull. ex Fr.) Fr.); **M. anthocephalus** (Sacc.) Sing. comb. nov. (*M. anthocephalus* Sacc.); **M. rugulosus** (Berk. & Curt.) Sing. (*M. rugulosus* Berk. & Curt.); **M. nigripes** (Schw.) Sing. comb. nov. (*Heliomyces nigripes* (Schw.) Morgan; *M. caesius* Murr.; *Gymnopus floridanus* Murr.[5]), and several other species not thoroughly studied by me. The section Androsacei Kühn. of Marasmius is closely allied with the rest of that genus.

XXI. Supplementary Data on Crinipellis and Chaetocalathus

Crinipellis trichialis (Lev.) Pat., Bull. Soc. Myc. Fr., 24 : 8. 1908

In my monograph on Crinipellis and Chaetocalathus (*Lilloa*, 8 : 511. 1942) I had to put this species among the "species incertae sedis." Additional material discovered in the Höhnel Herbarium (FH) under *Lentinus sp. indet.* has furnished enough descriptive data, however, to make it possible to dispose of the species within the subdivisions of the genus Crinipellis.

Crinipellis trichialis is macroscopically characterized by an umbonate pileus with a strongly hairy center from which emerges a brushlike hood consisting of erect fascicles of hairs, which are comparable in color to those of *Lentinus crinitus* (the darker forms); the lamellae are whitish and medium broad. Höhnel's material came from Buitenzorg, Java, and was collected on bamboo. Most of the hairs of the pileus are needle-like, often ladder-like at the apex, but a few are narrowed toward the apex and then suddenly rounded; they are golden melleous or (some) subhyaline; all are distinctly pseudoamyloid; they measure 5–9 μ in diameter, and the walls are 1.5–3.5 μ thick. The cheilocystidia are strongly incrusted with an amorphous resinous mass; they are numerous (edges of gills are heteromorphous) and measure 20–35 $\times$ 5.5–8.3 μ; a minority

[5] Not to be confused with *Marasmius floridanus* Murr., a common species of Marasmius of the warm zones of the Americas, and probably but a synonym of *M. fulviceps* Berk. I have studied the types of *Gymnopus floridanus* and *M. floridanus*, and of *M. caesius*, and also collected this well-characterized and common species in New York and Florida. It belongs to the Rameales group in spite of the unusual shape (angular) of its spores.

are entire or clavate, with sterigma-like clavulae at the apex, usually, however, with 2–4, rarely more, ramifications that branch off in the middle, or more commonly in the upper portion, of the cheilocystidium. The cystidia (pleurocystidia) are thick-walled or solid, opaque and refringent, mostly fusoid or narrowly clavate, hyaline, often with an appendage or a button-like tip, about as large or somewhat larger than the cheilocystidia, and numerous all over the sides of the lamellae. The spores are 8.2–8.8 × 5.5–5.8 μ, the ones that remain on the lamellae or on the hairs after maturity has been reached often become still larger, reaching 10.3 × 6.8 μ; they are short-ellipsoid (quotient Q not less than 1.5), nonamyloid, thin-walled, unicellular in age, hyaline or eventually becoming yellowish-hyaline, and without suprahilar depression. The hyphae are hyaline, thin-walled, nonamyloid, with clamp connections.

The conclusion is that this species belongs in the section Eucrinipellis, subsection Heteromorphinae, together with the African species *Crinipellis minutula* (Henn.) Pat.

Crinipellis minutula (Henn.) Pat., Ess. tax. Hym., p. 143. 1900

Lentinus minutula Henn., Engl. bot. Jahrb., 23 : 547. 1897.
Naucoria minutula Pilát, Ann. Myc., 34 : 123. 1936.
Phaeomarasmius minutulus Sing., Ann. Myc., 41 : 151. 1943.

In my *Monographic Study of the Genera Crinipellis and Chaetocalathus* (*Lilloa, loc. cit.*) I adopted Patouillard's transfer of this species from Lentinus to Crinipellis, and made it the type species of a new subsection (see preceding species). This was done on the basis of the material preserved in the Patouillard Herbarium, which was sent to Patouillard by Hennings and which may now represent the last remaining authentic material of this species. The part of the type that was preserved at Berlin-Dahlem (now probably destroyed) was studied by Pilát, who described the spores as colored, very small, and somewhat verrucose. This description, together with that of the hairs of the pileus (rather correctly described by Pilát), caused me to consider the plant a species of Phaeomarasmius (this combination was made long before I had a chance to see the type and was entirely *fide* Pilát). Since the rest of Pilát's description fits our part of the type rather well, only the spores being different,

I am convinced that here we have a duplication of what happened with *Lentinus cubensis*, in treating which Pilát described mold spores as basidiospores, and that otherwise his and my material are identical. Consequently, my disposal of this species in *Lilloa* was correct, and the combinations in *Annales Mycologici*, 1936 and 1943, based on Pilát's error in the description or interpretation of the spores, should be disregarded.

Chaetocalathus craterellus (Dur. & Lév.) Sing., Lilloa, 8 : 518. 1842

On pages 517–520 of the monograph cited above, this species was referred to its correct position and redescribed. A few supplementary notes and the correction of two unfortunate printing errors will, however, help avoid possible misunderstandings about *Chaetocalathus craterellus*.

In the key, under A I, the manuscript should read: "Stipe rudiment distinct, button-shaped. No pseudoamyloid cystidia present." The description of *Chaetocalathus craterellus* says "cystidia none." This statement is correct. The description fails, however, to mention the existence of cheilocystidia, which are numerous on the heteromorphous edge of the lamellae. They are polymorphous, a majority usually being forked or having small ramifications in the upper portion, hyaline, without contents, nonpseudoamyloid, and rather thin-walled. The hairs of the pileus often reach 7.5 μ in diameter. The spores were found to be 7.5–8 $\times$ 3.8–5.3 μ in other collections (which is in agreement with my description in *Lilloa*). The extension of the geographic area of this species to the tropics proper was in need of confirmation when my paper was written. Now I am in a position to assert the existence of *C. craterellus* in tropical Africa, for it was among material collected by G. W. Harley in Liberia. It differs from the Mediterranean materials merely in the lamellae being attached to the rudiment of the stipe, which is here rather small and, in some specimens, flattened to a mere disc, whereas in other carpophores it appears to be rather distinct. This tiny difference does not warrant the distinction of a tropical race or form. According to my present knowledge, *C. craterellus* occurs in the entire Mediterranean region, through the tropical belt of Africa, and along the western coast south to South Africa (if the latter

station is cited correctly by Pilát). This area is rather unique in mycology and can only be explained by a more detailed geobotanical investigation of the localities involved. The habitat in Liberia may possibly belong to the more xerophytic associations of that region.

The second error occured in the same key. Line B II b was omitted by the printer. It should read: "b. Pileus not red."

XXII. Position and Synonymy of *Clitocybe illudens*

Omphalotus olearius (DC. ex Fr.) Sing. comb. nov.

Agaricus olearius DC. ex Fr., Syst. Myc., 1 : 273. 1821.
Pleurotus olearius Gill., Hym. Fr., 1 : 344. 1878.
Agaricus illudens Schw., Schrift. Naturf. Ges. Leipzig, 1 : 82. 1822.
Clitocybe illudens Sacc., Syll., 5 : 162. 1887.[6]

American material of the species described as *Clitocybe illudens* is specifically identical with European material known as *Pleurotus olearius*. Both species have abundant clamp connections and peculiar cystidia (two types), which are, perhaps, more properly described as pseudoparaphyses or cystidioles. One of these types occurs most frequently on and near the gill edges and originates from a basidium whose sterigmata (from one to several) take the shape of appendages, become much longer than usual, and fail to discharge spores; the upper part of the appendage is, however, occasionally separated from the "cystidium." In the other type of "cystidium," the lower portion is likewise basidiomorphous, but the apex is button-like, and it remains sterile; this "cystidium" is often found on the sides of the lamellae, also. The context turns cinnamon color (positive) with methylparamidophenol and is stained grayish by $FeSO_4$. Other reagents (HNO_3, KOH, NH_4OH, aniline, formalin, and so on) cause no, or very little, change in color. The wall of many of the spores tends to become rather thick (though simple), a character reminiscent of Armillariella. The trama is rather irregular, without the slightest trace of bilaterality, and with a general trend toward an axillar arrangement; some of the hyphal walls are moderately thick.

All these data prove that the species belongs neither to Clitocybe nor to Pleurotus, and it cannot be regarded as a species of Armil-

[6] Additional synonyms are indicated by R. Maire (*Bull. Soc. Hist. Nat. Afr. Nord*, 7 : 191. 1916) and by Konrad and Maublanc (*Icon. Selectae*, 6 : 335. 1937).

lariella because of the absence of clamps in the latter genus. The general appearance, the luminescence, and the strong pigmentation make it outstanding enough to warrant separation into an autonomous genus, as was suggested by Fayod fifty-seven years ago. Since Fayod did not actually make the combination *Omphalotus olearius*, I propose it here as the valid name of this species.

XXIII. Two New Species of the Pleurotoideae

Pleurotus floridanus Sing. sp. nov.

Pileo albo vel centro pallide alutaceo, subtiliter villosulo vel subglabro, levi vel sublevi et ad marginem haud sulcato, convexo, dein irregulariter concavo, statu intermedio subplano saepe observato, mox infundibuliformi, 30–75 mm. lato. Lamellis albis in vegetis, confertissimis, angustissimis (1 mm. latis), integris ad aciem, profunde decurrentibus; sporis albis, sub microscopio hyalinis, levibus, haud amyloideis, ellipsoideis vel subcylindraceis, 4–5 × 2–2.8 μ; basidiis tetrasporis, 20 × 4–4.8 μ; cystidiis numerosis, crassitunicatis vel ad apicem solidis, crystallino-capitatis in compluribus, fusoideo-ampullaceis vel ventricoso-capitatis, fortiter ventricosis in centro, 20–25 μ projicientibus, apice obtuso instructis, haud pseudoamyloideis, membrana 0.7–4 μ crassa, plerumque plus 1 μ, saepe 1–2 μ crassa, hyalina praeditis, 31–56 × 8–13.5 μ; tramate ex hyphis hyalinis, intertextis, tenuissimis, membranis subincrassatis instructis efformato, haud amyloideo; subhymenio lato, distincto. Stipite albo, demum pallide brunneolo, subtiliter villoso, basin versus subattenuato vel irregulari, saepe ramuloso, solido, saepe concrescente, 14–40 × 3–10 mm.; tomento basali fibrilloso, ex hyphis filamentosis, fibulatis consistente, hyphis terminalibus saepe clavatis atque usque ad 7 μ latis. In truncis frondosis (indeterminatis, vetustis). Highlands Hammock State Park, Highlands County, Florida, U. S. A. R. Singer, F-217 (FH).

Observations. — This species differs from the known species of Panus in being white and in having a distinct subhymenium. Other white species of Pleurotus lack the characteristic cystidia.

Resupinatus chilensis Sing. sp. nov.

Pileo in siccis griseolo, sub lente tomentoso, dimidio externo sulcato, resupinato, anguste campanulato, pendulo, base attenuata

adnexo, margine primum incurvato, dein obtuso, 1–2 mm. lato; cuticula consistente ex hyphis jacentibus, intertextis, densis neque gelatinosis, indistinctis incrustationis causa, saepe ramulos breves emittentibus, ad aciem lamellarum de margine pilei transeuntibus. Lamellis pallidioribus, venosis, acie obtusis, ad marginem tomentosis, ascendentibus, radiantibus, angustissimis, subanastomosantibus, distantibus (interdum una vel tribus tantum), parte sua interiore approximantibus sese ita ut hymenophorum frequenter porosum (Favolaschiarum modo) videatur; sporis 6.3–7.5 × 4.2–6.3 μ, regulariter breviterque ellipsoideis, hyalinis, levibus, inamyloideis, tenuitunicatis; basidiis 28–29 × 6.3–7 μ; corpusculis sterilibus in hymenio nullis, sed cheilocystidiis indistinctis pseudophysoideis observatis; tramate ex hyphis hyalinis, irregulariter undulosis in massa gelatinosa, tenuibus, haud amyloideis, fibulatis consistente. Carne exigua. In lignis mortuis; admodum gregatim. Prope Punta Arenas, Chile. R. Thaxter (FH).

Observations. — This species differs from most other species of the genus Resupinatus (= Scytinotopsis Sing.) in the strange, narrowly bell-shaped carpophores and the narrow distant lamellae.

XXIV. Tramal Structure and Taxonomic Position of Termitomyces Heim

Termitomyces eurhizus (Berk.) Heim, Arch. Mus. Nat. Hist. Natur., VI, 18 : 140. 1943

Rajapa eurhiza (Berk.) Sing., Lloydia, 8 : 143. 1945.

Additional material that has come to my attention shows clearly the bilateral hymenophoral trama. The material consists in part of well-preserved young caps gathered in Indo-China; older specimens of the same collection show the trama exactly as described by me (*loc. cit.*), i.e. regular. The mediostratum is composed of parallel, densely packed, and rather thin clampless hyphae; the lateral stratum consists of less straight, less densely arranged hyphae, curved and divergent from the mediostratum toward the hymenium. All these specimens are ringless, and it is probable that the specimens sent to Patouillard by Petch (FH), with distinct annulus and heavier, larger carpophores, are, though certainly closely related, nevertheless specifically different (*Agaricus albuminosus* Berk.).

The trama found in these specimens from tropical Asia is com-

parable to the trama of Limacella (where, however, the septa are clamped), rather than to that of Pluteus and Volvaria. This assures the genus autonomy even among the Amanitaceae, if it should be transferred there on the basis of the tramal anatomy.

War conditions made it impossible to keep informed of papers appearing abroad, and I have unfortunately published a new generic name (Rajapa) for a genus already described by Roger Heim. Nonetheless, the fact that both Heim and I, starting from entirely different material and different experiences, have come to practically the same result independently, viz., the erection of an autonomous genus for species of the type *Termitomyces eurhizus*, and the like, is in itself very satisfactory. We now have one more unnecessary synonym, but we also have conclusive proof that two authors, who sometimes differ on minor matters of taxonomy or in problems of theory, but both of whom use the methods of modern mycological taxonomy, will arrive at the same solution in systematics if all factual observations are correctly made.

As for Heim's work, I refer the reader to the following publications (1940–43):

1. Culture artificielle des mycotêtes . . . . Comp. r. Acad. Sci., 210 : 410–412. 1940.
2. Études descriptives et expérimentales sur les agarics termitophiles d'Afrique tropicale. Acad. Sci. Inst. France Mem., 64 : 1–74, pls. I–X. 1941.
3. Les Termitomyces dans leurs rapports avec les termites pretendus champignonnistes. Comp. r. Acad. Sci., 213 : 146–148. 1941.
4. Les Champignons des termitières. Rev. Scient., 80 (3205) : 69–86. 1942.
5. Nouvelles études descriptives sur les agarics termitophiles d'Afrique tropicale. Arch. Mus. Nat. Hist. Natur., 18 : 107–166. 1943.

Termitomyces LeTestui (Pat.) Heim, Arch. Mus. Nat. Hist. Natur., VI, 18 : 109. 1943

The type of this species is preserved at the Farlow Herbarium. Since the tramal structure was not known, I compared the part of the type marked "état jeune" — all three collections are identical, by the way, even the "forme sans anneau" — and found the trama bilateral, with axillarly arranged interwoven hyphae composing the mediostratum and looser, more hyaline, curved-divergent hyphae forming the lateral stratum. All these hyphae are rather thin, filamentous, and nonamyloid, devoid of clamps.

The data above show that in the deep-colored, large species of the

African Termitomyces the trama is bilateral, just as in the Asiatic species. They also show that Heim was right in his delimitation of the genus. We may now conclude that the trama is bilateral (not reversed) in young specimens of Termitomyces and that it later becomes regular in this genus, the trama being a constant generic character here as elsewhere. The persistent absence of clamp connections in all species of Termitomyces gives additional evidence of the value of this particular character, whose importance has been emphasized by me in several previous papers (see *Lloydia*, 5 : 98. 1942).

Termitomyces congolensis (Beeli) Sing. comb. nov.

Lepiota congolensis Beeli, Bull. Soc. R. Bot., B. : 109. 1927.

Material has been received from Liberia (G. W. Harley, 21 [FH]) that is identical in all characters with *Lepiota congolensis* Beeli. I have compared this material with *Termitomyces LeTestui*, which differs strongly in appearance, especially in the rugose surface and the peculiar shape of the pileus; yet these species are evidently very close to each other. It is remarkable that neither Beeli nor Harley mentions termites at all, but we agree with Heim that the long pseudorhiza obviously leads down to termite nests, which are invisible from above to the unsuspecting collector.

XXV. Chlorophyllum Mass. and Macrolepiota Sing.

Chlorophyllum molybdites (Mey.) Mass., Kew Bull., p. 136. 1898

Agaricus molybdites G. Meyer, F. Essequ., p. 300. 1818, ex Fries, Epicr., p. 13. 1836.
Agaricus Morgani Peck, Bot. Gaz., 4 : 137. 1879.

The following description is the result of studies on fresh material I collected in Florida and compared with the type specimen of *Agaricus Morgani* Peck. I do not know whether there is a type specimen of *A. molybdites*, but it seems to be the general agreement that this species, very common in the American tropics, is the one that Meyer described.

Pileus buffy white (rarely pinkish when still smooth and closed), beset with minute fibrillose to flocculose scales, which are detersible

and brownish, more so on the margin, but eventually often glabrescent, the disc covered by a "wood-brown" (R.) to "mummy-brown" cortex, which breaks up sooner or later centripetally into semierect, irregular, brown scales, not sulcate or with rather indistinct, very short furrows on the margin of the oldest specimens, dry, campanulate with broadly rounded top, then convex to conic-convex or globose-convex, then flatter, frequently with a distinct umbo, 47–190 mm. broad. Lamellae glaucous-pallid, soon becoming "tea-green" (R.) to "dark glaucous gray," sometimes staining reddish or brownish when injured, remote-free, moderately broad (up to 10 mm. broad), close to crowded; spore print in the color of the lamellae or "bice-green," "deep grape-green," "grape-green," "pois-green." Stipe pure white to whitish pallid, eventually with brownish stripes or uniformly brownish, glabrous, naked, annulate, solid, then stuffed, then with loose cottony stuffing in the hollow (as in *Coprinus comatus*), tapering upward or equal, but bulbous below, 70–200 × 10–14 mm., the bulb 11–35 mm. in diameter; annulus concolorous with the stipe, or the central layer brownish at the margin, with a triple border, of the structure of an annulus of the Proceri group, initially fixed, but by shrinking becoming movable, free, and often sliding down the stipe. Context white, reddening on injury or remaining unchanged, especially in dry weather and in old specimens, and then the apex of the pileus "buckthorn-brown" inside and the context of the cortex of the stipe more or less brownish; odor very agreeable, of perfume or fruit, even in dried material; taste mild.

Spores 10.2–13 × 6.8–8.8 μ, hyaline to greenish hyaline, smooth, with thick, triple wall and distinct germ pore, the wall pseudoamyloid, in many spores the exosporium separated from the endosporium by an intermembranal layer or space that often appears to be pink in KOH-phloxine, the entire spore, including the endosporium, becoming bright and deep blue if dyed with neutral brilliant cresyl blue, the metachromatism of the wall either absent or obscured by the strong absorption of the blue by the spore; basidia about 42 μ long, 11.5–12.5 μ broad, 4-spored; cheilocystidia versiform (often clavate), 40–60 × 10–16.5 μ; trama subregular, of cylindric-filamentose hyaline or greenish-hyaline nondivergent hyphae; the context of the stipe deeply entering that of the pileus and distinctly separate from the latter in sections; the brown cortex of the disc consisting of strongly interwoven or semierect to repent strands of parallel

agglutinated brownish hyphae, often partially intermixed because of the larger diameter of many hyphae, some hyphae with slightly thickened walls, most of them rather thin; annulus consisting of rather parallel, rather dense, hyaline, thin-walled hyphae, on its surface some velo-cystidia which are mostly clavate, 23–35 × 10–12 μ; all hyphae nonamyloid, without clamp connections.

Chemical characters. — Methylparamidophenol reaction on the context negative at first, eventually turning it brown, more so in the stipe, less so in the pileus, even the spore print browning with this reagent.

Habitat. — On lawns, in plantations, in open woods and parks under various trees, on improved garden earth, in ruderal places, on sandy soil even though containing some salt, occasionally in abandoned gardens overgrown with second-growth tropical hammock, on the ground; gregarious; fruiting from April until November in the Northern Hemisphere, fruiting in winter in the Southern Hemisphere.

Distribution. — Probably pantropical, in America reaching deep into the temperate zone (north to New York and Michigan), in Europe only in greenhouses; most abundant in America and Oceania.

Florida material studied. — Dade County, Fairchild Tropical Garden, R. Singer, F–1376 (FH), Brickell Hammock, R. Singer, F–1376a (FH); Highlands County, Highlands Hammock State Park, A. Altvater, F–86 (FH); Alachua County, Gainesville, W. A. Murrill and R. Singer, F–86a (FH), R. Singer, F–86b, F–1953 (FH).

Var. **luteolosperma** Sing. var. nov.

A typo sporis in cumulo luteolis recedit.

Observations. — This variety (type from Gainesville, Alachua County, Florida, R. Singer, F–1953a [FH]) differs in the "deep colonial buff" (R.) spore print and lamellae; the context tends to become reddish as well as yellow on injury. It grows solitary at the type locality.

Kühner (*Comp. r. Acad. Sci.*, 198 : 843 (1). 1934) indicates an interesting metachromatism in the spore preparations of *Lepiota procera* that were dyed with cresyl-blue. I checked on this character not only in *L. procera* but in most other species of the Proceri group, including such species as *L. Badhamii* and *L. naucina*, and always

found the pinkish to pale lilac-pink endosporium contrasting with the violet-pallid exosporium. All the species of Hiatula (sensu Heim and Romagnesi) show the same metachromatism. None of the species of Lepiota sensu stricto which I have checked (*L. clypeolaria*, *L. clavipes* Henn., *L. acutesquamosa*, and so on) showed this metachromatism, the endosporium either appearing in the same shade as the exosporium or not developed at all. In a series of recent papers Locquin reunites the groups having spores that can be dyed metachromatically with cresyl-blue and having thick walls and a germ pore under the common name Leucocoprinus Pat. He thinks, as I do, however, that the groups making up this supergenus are eventually to be regarded as its generic elements — although he now treats them as subgenera. This treatment, though in my opinion taxonomically sound, is untenable from a nomenclatorial point of view, since Patouillard based his genus on a species of the Hiatula type (but annulate), and if Hiatula is included in the same genus as *Lepiota procera*, one has to use the older generic name "Hiatula" instead of "Leucocoprinus Pat." If, however, Hiatula and the other subgenera are considered independent genera, it is obvious that the Proceri group remains without a generic name, unless Chlorophyllum can be considered to be congeneric with it. Patouillard, Heim, and I (1943) were inclined to think that Chlorophyllum is congeneric with the Proceri group, whereas Massee, Murrill, and others admitted Chlorophyllum in addition to the genus containing the Proceri group.

In the light of the description of *Chlorophyllum molybdites* above, I am now inclined to believe that Chlorophyllum should be generically separated from the Proceri group. The structure (the intermembranal space), color (green or colonial buff) and susceptibility to dye (brilliant cresyl-blue coloring the whole spore uniformly deep blue, like the gloeocystidia of the Aphyllophorales), the presence of a rather violent poisoning matter, and the absence of clamp connections put this species in obvious contrast to the Proceri group. So long as these characters were either unknown or not considered to play an important rôle in the taxonomy of the Leucocoprinaceae, we were entitled to regard *C. molybdites* and *Lepiota procera* as congeneric. Now we must separate them, in spite of the external similarity of the carpophores. We cannot, however, exclude Chlorophyllum schematically from the group Leucocoprinus sensu Locquin merely

on the basis of the action of the dye. On the contrary, I propose to include Chlorophyllum Mass., together with the Procceri group, Clarkeinda Kuntze (= Chitoniella Henn.), Schinzinia Fayod, and possibly some of the new subgenera published by Locquin, in the same tribus, which I propose to call:

Leucocoprineae trib. nov.

Sporis pseudoamyloideis, crasse tunicatis, membrana duplici (vel triplici), poro germinativo plus minusve distincte interrupta, tinctura cresylo-cyanea ("brilliant cresyl-blue") metachromatice tinctis (raro monochromatice tinctis et tunc in cumulo viridibus vel alutaceis); annulo saepe mobili, frequenter multistratoso, *aut* pileo ad marginem plicato-sulcato. Genus typicum:

Macrolepiota Sing. gen. nov.

Sporis majusculis vel giganteis, membrana metachromatice tincta tinctura cresylo-cyanea, in cumulo albis vel cremeis (vel roseis?); hyphis fibuligeris. Species typica: **Macrolepiota procera** (Scop. ex Fr.) Sing. comb. nov. (= *Lepiota procera* auctor.).

Observations. — The tribus Leucocoprineae is here distinguished from the tribus Lepioteae (genus Lepiota S. F. Gray sensu stricto and perhaps Pseudobaeospora Sing. and Schulzeria Bres.) and also from one or two more tribes to be described for the genera Cystoderma Fay., Smithiomyces Sing., and Drosella Maire.

STROPHARIACEAE

XXVI. Redescription of *Deconica crobula* from America

Deconica crobula (Fr.) Romagnesi, Rev. d. Myc., 2 : 244. 1937 (sensu Lange, Fl. Ag. Dan., 4 : 28. 1939)

Tubaria crobula (Fr.) Sacc., Syll., 5 : 876. 1887.

Pileus "Rood's brown" (R.), strongly hygrophanous, opimous-subviscid, not glutinous, smooth, very minutely and indistinctly striatulate by transparence on the margin, convex to flat, with a small umbo, 8–14 mm. broad. Lamellae between "avellaneous" and "wood-brown," paler-fringed, moderately broad for a Deconica but actually rather broad, broadly adnate but not at all decurrent,

moderately close or subclose; spore print bister-sepia. Stipe concolorous with the pileus or paler at the apex, much deeper colored (bay-fuscous) at the base, but almost entirely covered with fibrillose squamules derived from the veil, leaving only a small part of the apex naked, subequal or equal, 14–32 × 1–1.5 mm.; veil white on the stipe, initially also very strongly developed on the margin of the pileus, where it forms silky, detersible, appressed fibrils which often agglutinate to form pure-white, irregularly distributed small flocci; a well-formed annulus usually wanting. Context paler, in the stipe rather deep brown; odor and taste not remarkable.

Spores 5–6.7 × 4.2–5.5 μ when seen frontally, narrower when seen in profile (3.3–4.2 μ), lentiform, but not distinctly rhomboidal, with a fuliginous tint, smooth, with double wall and wide flat germ pore; cheilocystidia 27–38 × 5–5.5 μ, with a ventricose lower portion and a long filiform apex, which is 2–2.5 μ broad and obtuse; epicutis composed of repent, filamentous, hyaline hyphae with clamp connections.

Observations. — This species was found on logs under Carya, gregarious, June 24, 1945 (R. Singer and H. Dadmun [FH]), at Harvard, Mass. Except for being very slightly larger, the species coincides in all important characters with the species described as *Tubaria crobula* by Lange. The plant described as *Deconica crobula* by Romagnesi differs markedly in a few characters and is probably identical with what some authors consider the lignicolous form of *D. inquilina*, whose typical form (in our conception) is graminicolous. It may be that the grass form should be called *D. ecbola* (Fr.); Romagnesi's form may be called *D. inquilina*, and the form described above, *D. crobula*. These observations are not intended to anticipate anything so far as the proper interpretation of the Friesian species goes. This must be left to the monographer.

Another common species of Deconica in New England is *D. atrorufa* (Batsch ex Fr.) Sacc. (which may be the same as *Psilocybe polytrichicola* Peck).

XXVII. A New Species of Pholiota

Pholiota Maackiae Sing. sp. nov.

Pileo centrum versus sordide brunneolo-ochraceo, ad marginem aeruginascente, squamis punctiformibus in disco asperso demum ni-

grescentibus et spiniformibus, pellicula viscida praedito, in siccis nitente, veli vestigiis ad marginem visibilibus, convexo, magnitudine mediocri. Lamellis olivascente-argillaceo-brunneis, aciebus flavis, latissimis, subconfertis, late adnexis, partim subdecurrentibus-subsinuosis; sporis 5–7.7 (8.8) × 4.5 (5) μ, poro germinativo indistincto inconstanteque praeditis, levibus, ochraceo-brunneolis, paucis obscure brunneis; basidiis 20 × 6.6 μ; cystidiis et cheilocystidiis praesentibus, ampullaceis, ad basin in stipitem 5–10 μ longum attenuatis, parte media ventricosis, 9–11.5 (25) μ latis, apice 5–6.6 μ latis, raro subcapitulatis, 35–53.5 μ longis, tenuitunicatis, hyalinis, pleurocystidiis tantum vivide luteis et lucem fortiter refringentibus; acie heteromorpha. Stipite pallide flavido, ferrugineo-ochraceo ad basin, annulo subcaduco, subtili, ascendente-distante, fibrilloso, mediano instructo, squamis destituto, ad apicem attenuato vel base subincrassato, longitudinaliter compresso et subexcentrico, curvato, magnitudine *Pholiotam luciferam* aemulante. Carne sicca pallide luteola. In trunco *Maackiae amurensis*, Septembri mense 15, 1939, Coll. Lyubarski in regione Khabarovskensi. The type locality is in the U.S.S.R., Far Eastern region, Khabarovski kray; sixty-nine km. from the branching of the Oborski L. P. Kh. R.R. The type is preserved in Leningrad; cotype material is probably available at Khabarovsk.

CORTINARIACEAE

XXVIII. Redescription and Transfer of *Pholiota confragosa*

Naucoria confragosa (Fr.) Sing. comb. nov.

Pholiota confragosa (Fr.) Karst., Hattsv., p. 304. 1879.

Pileus flesh-color-cinnamon, cinnamon-rufous, subglabrous to innately scurfy-fibrillose, hygrophanous, pale buff or a very pale cinnamon-buff when dry, with striate margin which becomes smooth when dry, nonviscid, convex-umbilicate, 26–50 mm. broad. Lamellae pale rufous to cinnamon, with a slight olive-cinnamon tinge, nearly burnt ocher when old and dry, with slightly fimbriate, pallid edge, flatly adnate, narrow (up to, and usually as much as, 3 mm. broad), subclose to close; spore print dirty ferruginous burnt ocher (Séguy, No. 336). Stipe carneous-brownish white at the apex and merely subsericellous there, gradually darker below the annulus,

reaching a shade similar to the color of the pileus, covered with pale carneous-brownish or pale pinkish-cinnamon squamulae up to the annulus, on whose lower side they may form a definite zonation by leaving the outer margin of the annulus naked, but not always clearly delimited, white-tomentose at the very base; stuffed, then hollow, reaching 10 mm. at the base and tapering to the apex, where it is up to 5 mm. broad, up to 80 mm. long; annulus at first distant, horizontal to suberect, later partly or entirely pendulous, rarely evanescent, striatulate above, carneous-brownish-pallid, superior. Context hygrophanous, subconcolorous with the surfaces, almost reddish when dry; odor lacking; taste mild.

Spores bean-shaped, frontally egg-shaped, with the longitudinal sides often almost plane (straight) and the ends rounded, 7–8.5 × 4–5.8 μ, smooth, pale ferruginous, with one large or several small oil droplets, the wall indistinctly double but moderately thick, without a distinct germ pore; basidia 21–23.5 × 5–6 μ, 4-spored; cheilocystidia 45–70 × 8–8.5 μ, at the apex 3–4 μ thick, hyaline, usually subulate-elongate, with thin to slightly thickened (0.8 μ) wall, with obtusely rounded, rarely somewhat capitate, apex, borne on subisodiametric cells; cystidia lacking; edges of gills heteromorphous; subhymenium cellular; trama regular, consisting of hyphae up to 9 μ in diameter; epicutis of the pileus composed of a palisade of crowded erect dermatocystidia; these dermatocystidia bearing a terminal member that is often similar in shape to the cheilocystidia (with which they are homologous), or more cylindric, usually with rounded tips, 23–35 (66) × (10) 11–15 μ, rarely as elongated as 66 × 10 μ, rarely mucronate, walls more or less thickened (1–1.7 μ in diameter), pigment-incrusted (brown), otherwise hyaline; hypodermium consisting of filamentous hyphae which are occasionally rough, always repent, brownish; annulus consisting of filamentous hyphae, some of them rough; all hyphae with clamp connections. KOH on the pileus causing immediate blackish-brown discoloration.

Habitat. — On old or very decayed stumps (Fagus, Betula, Picea) and on scattered sticks and débris on the ground in open mixed woods, caespitose to (sometimes) subfasciculate, more rarely some individuals growing singly, fruiting from July to September.

Distribution. — Most of northern England, Scandinavia, Finland, Leningrad region and east to Siberia; much rarer in Central Europe (mostly in the montane zone, especially in the Alps and the

Carpathians); also in the northeastern United States (New York and the New England states), and probably in Canada; the western limits unknown.

Observations. — This is not a species of Gymnopilus (neither is it, of course, a species of Pholiota) or of Fulvidula, as has been suggested by me previously (*Rev. d. Myc.*, 2 : 239. 1937), but, as the description above immediately suggests, a large annulate species of Naucoria (Fr.) Quél. I accept, as in my previous papers, the genus Naucoria in the sense in which it has been restricted by me, i.e. with *N. centunculus* and closely related species included, all other species referred to other genera (Galerina, Agrocybe, Alnicola, Phaeocollybia, Phaeomarasmius, and so on).

The description above is based on material collected by the writer in the Leningrad region and in the Karelo-Finnish Republic, also in Tyrol (Austria) and other places.

XXIX. Two New Cortinariaceae

Tubaria thermophila Sing. sp. nov.

Pileo lateritio-badio-spadiceo, colore primum *Leucopaxillum amarum* fere in mentem revocante, dein cinnamomeo-brunneo vel ferrugineo-brunneo (squamulis vel fibrillis marginis "Mikado brown" Ridgwayi, centri "amber-brown"), dense tomentoso, mox in squamulas fracto, squamulis confertissimis, minutis, subfibrillosis ad marginem, ad centrum distinctioribus, cuticula saepe subrimulosa ad marginem extremum instructo, convexulo-planiusculo, dein plano, demum concavo, 22–30 mm. lato; cuticula ex hyphis repentibus, jacentibus, irregularibus, fibuligeris, saepe pigmentatis pigmento epicellulari (intercellulari), amorpho et intracellulari, dissoluto, nonnullis guttulis impletis glococystidiorum modo consistente. Lamellis albido-gilvis vel albidis, dein sordide argillaceis vel pallidissime griseo-incarnatis, sinuato-decurrentibus vel fortiter decurrentibus, subangustis, confertis vel confertissimis; sporis dilute sed laete ferrugineis, verruculosis, disco suprahilari levi nullo, breviter fusoideis, centro crassissimis, ad apicem angustatis, depressione supra-hilari notata, 8–9 × 6–6.5 μ; basidiis clavatis (1) 2-sporis, 13.5–23 × 7.5–8.5 μ; cystidiis nullis; cheilocystidiis hyalinis, versiformibus, plerumque clavatis vel subclavatis, nonnullis subfusoideis, apicem versus angustatis vel late rotundatis, nonnullis interdum digiti-

formiter appendiculatis digitis uno vel duobus, nonnullis semierectis vel ascendentibus vel agglutinatis; subhymenio e cellulis brevissimis parvulis consistente; tramate lamellarum hyalino, subregulari. Stipite albo, raro in parte subcitrinello, glabro, nitente, solido, subaequali vel base subincrassata praedito, 29–68 × 2–4 mm.; velo haud manifesto. Carne albida, inodora, miti; hyphis fibuligeris. In dumetis subtropicalibus humidissimis in terra humoso-sabulosa vel nonnunquam nucibus *Caryae megacarpae* affixi vel e ligno mucido ecrescentes, aestate. Highlands Hammock State Park, Florida, U. S. A. R. Singer, F–20, F–20a (FH).

Galerina hypnorum (Schrank ex Fr.) Kühner var. **evelata** Sing. var. nov.

A forma typica sporis calyptratis, colore intensiore laetioreque, veli absentia differt; a forma *calyptrospora* Kühn. absentia veli coloreque differt.

Pileus ochraceous-fulvous, hygrophanous, drying from the top downward, more than half the radius transparently striate, smooth and pale ochraceous or alutaceous-pallid when dry, not viscid, glabrous, at first subcampanulate, obtuse, later conico-convex, about 5 mm. broad when mature. Lamellae ochraceous, rather distant, at first adnate, subascendant, later adnexed to adnate, subhorizontal. Stipe subconcolorous with the pileus, smooth, glabrous, filiform, variable in length, about 1 mm. thick; veil lacking even in young specimens. Context very thin, subinodorous.

Spores 11–13.5 × 6.8–8.2 μ, with a saccate perisporium; cheilocystidia 40–50 × 11–13.7 μ, ampullaceous, with strongly ventricose base (as in *Galera cerina* Bres.) and with a cylindric or pencil-shaped apex, rarely capitate or obtusely conic, apex 6.7–8.2 μ in diameter; basidia 4-spored; hyphae with clamp connections.

Observations. — The type of this variety is one of the specimens collected by the writer on Mount Washington between 5,000 and 5,500 ft., i.e. in the subalpine zone of the White Mountains, New Hampshire (WM–3, WM–21, FH), under rather severe climatic conditions (strong winds and low temperatures, but with sufficient moisture during most of the year), in August, 1945. Other specimens that may be referred here were collected in the Altai Mountains (R. Singer, A–765 [LE]), under similar climatic conditions,

near Lake Teletskoe, Oirotia, in August, 1937. It is characteristic that farther south and at a lower altitude in New England (e.g. in Massachusetts) — even later in the fall — the type variety of *Galerina hypnorum* is observed, a form agreeing well with Kühner's description and the writer's notes on the bisporous form of the European type.[7] Furthermore, the specimens from the dry habitats of the Kosh Agatch valley in the Altai Mountains proved to be different from var. *evelata*. Additional observation of the young specimens as regards the color of their pileus and the correlation of the occurrence of a perisporium should show whether this is an adaptation to cold and not-too-dry habitats in the mountains or a definite geographic race, or perhaps an independent species.

It is possible that *Galerula subhypnorum* Atk. is identical with *Galerina hypnorum* var. *evelata* Sing.; not knowing the type, however, I am unable to interpret Atkinson's species one way or another.

BOLBITIACEAE

XXX. New Species of Bolbitiaceae

Bolbitiaceae fam. nov.

Epicutis elementis sphaerocystoideis vel piriformibus hymeniformiter dispositis; sporis laetissime ferrugineis vel rarius ferrugineo-fuscis in massa vegeta, levibus, membrana complexa, poro germinativo plerumque praesente; basidiis plerumque breviusculis et crassis, saepissime 2-sporis in formis parallelis normalibus tetrasporis; cheilocystidiis praesentibus; (pleuro-)cystidiis saepe differentiatis; dermatocystidiis plerumque praesentibus aut in pileo aut in stipite. Fibulis in formis tetrasporis praesentibus. In terra, saepe in pratis, interdum in fimo, rarius in lignis. Cum Coprinaceis comparanda, sed ferrugineospora familia. Genus typicum: Bolbitius Fr.

Observations. — The old subfamily Bolbitioideae Sing. was certainly a good natural unit; with the disintegration of the family Cortinariaceae, however, this subfamily should, in my opinion, now be considered an independent family. It contains the genera Pholio-

[7] The 4-spored form was found in many places in Europe, where it is very common, e.g. Peterhof, Leningrad region, R. Singer, M4–183 (LE). Forma *calyptrospora* Kühn. was studied in Karelia (197–M4–326 [LE]), and was in full agreement with Kühner's original description.

tina Fay., Galerella Earle, Tubariopsis Heim, Conocybe Fay., Bolbitius Fr., Cyttarophyllum Heim, and Agrocybe Fay.

Pholiotina rugosa (Peck) Sing. comb. nov.

Pholiota rugosa Peck, Ann. Rep. N. Y. State Mus., 50: 102. 1897.

This species has been well described macroscopically by Overholts, and all that is needed is a revised microscopical description:

Spores (8.2) 9.5–11.2 × 4.8–5.8 μ, ellipsoid, seemingly rough because of the granular contents, with moderately thick, compound walls, bright ferruginous fulvous-brown, but not with the very deep color found in Conocybe, with a distinct broad germ pore; basidia 31.5 × 9.2 μ, 4-spored; cheilocystidia about 40 × 10 μ, numerous, ampullaceous; hyphae of the gill trama of the Pholiotina type; epicutis of the Pholiotina type; all hyphae with clamp connections.

Observations. — Our specimens were 7–25 mm. in diameter when fresh; the stipe had a median, more rarely subapical, annulus, which is persistent or slides downward to the somewhat bulbous base; the odor was slightly raphanaceous; in most specimens a broad obtuse umbo was present; the wrinkled surface was not very striking, but was usually clearly apparent; the lamellae were horizontal and adnexed, slightly ventricose in mature specimens. This collection came from the greenhouses of the Waltham Field Station, Massachusetts, E. V. Seeler, February 16, 1944.

The characters of this species are evidently those of a Pholiotina, and therefore it is proposed that Peck's species be transferred to that genus.

GOMPHIDIACEAE

XXXI. Latin Diagnoses of New Units of the North American Gomphidius Flora (Preliminary Account)

Gomphidius leptocystis Sing. sp. nov.

Pileo demum floccoso-squarruloso, ochraceo vel aurantiaco, lignicolori vel avellaneo in margine, purpurascente siccando; lamellis cystidiis tenuitunicatis, hyalinis, incrustatis, collabentibus obsitis; sporis pro ratione iis *Gomphidii tomentosi* minoribus; stipite concolori; carne subconcolori-pallidiore; ceterum *Gomphidio tomentoso* et *Gomphidio ochraceo* simillimus est. In silvis coniferis Americae

Borealis occidentalis. Typus in Vancouver, Canada, collectus atque in Herbario Michiganensi conservatus est.

Gomphidius vinicolor Peck ssp. nov. **californicus** Sing.

A typo cystidiorum abundantia inconsueta constanter differt; mycelio cum *Pinis radiatis* et *Pinis ponderosis* associatus.

Gomphidius ochraceus Kauffm. ssp. nov. **muscigenus** Sing.

A typo pileo haud ochraceo-aurantiaco et probabiliter associatione mycorrhizina differt. America Borealis.

Gomphidius, subgenus **Laricogomphus** Sing. subgen. nov.

Carne plus minusve rubente, velo subnullo; subhymenio filamentoso, moderate denso; mediostrato moderate distincto in maturis; dermatocystidiis stipitis fasciculatis plerumque glandulas distinctas formantibus; mycorrhiza cum laricibus.

Gomphidius, subgenus **Myxogomphus** Sing. subgen. nov.

Carne pilei alba vel roseola vel fracta nonnihil rosascente; velo bene evoluto, ex hyphis haud incrustatis subparallelo-subintertextis consistente; subhymenio filamentoso vel filamentoso-subcellulari, moderate denso; mediostrato moderate distincto in maturis; dermatocystidiis stipitis sparsis, haud fasciculatis, glandulis nullis; mycorrhiza variis cum coniferis sed vix cum laricibus observata.

Gomphidius, subgenus Myxogomphus, sec. **Macrosporus** Sing. sec. nov.

Sporis maturis 14 μ majoribus.

Gomphidius, subgenus Myxogomphus, sec. **Microsporus** Sing. sec. nov.

Sporis 14 μ brevioribus.

Gomphidius septentrionalis Sing. sp. nov.

Pileo roseolo, viscido, glabro; lamellis ex albo grisellis; sporis 15.7–22.5 × 6–8.5 μ; stipite elongato, parte basali laete lutea, velo zonas unam vel duas vel tres glutinosas, angustas ad apicem stipitis

formante vel ex integro membranaceo nec stipitem late cothurnante; carne salmonea, subtus lutea. In silvis piceino-abietinis cum *Boletino glanduloso* in parte septentrionali-orientali Americae Borealis; *Gomphidio roseo* proximus.

Gomphidius Smithii Sing.

Pileo dilute purpurascente-vinaceo vel pallide griseolo-vinaceo; lamellis grisascentibus; sporis 15–19.5 × 5.5–6.5 μ; cystidiis actione formaldehydi in sectionibus KOH imbutis in speciminibus recenter exsiccatis pulchre purpurascentibus; stipite 50–80 × 8–12 mm., albo, hyalino-glutinoso et cothurnato; carne alba, laesa aeris actione rosascente ut minimum in base stipitis, $FeSO_4$ ope atrata. Sub *Pinis contortis* et *Pseudotsugis taxifoliis*. Oregon Americae Borealis.

Var. xanthobasis Sing.

A typo base lutea differt. Sub *Pinis flexibilibus* in Massachusetts introductis.

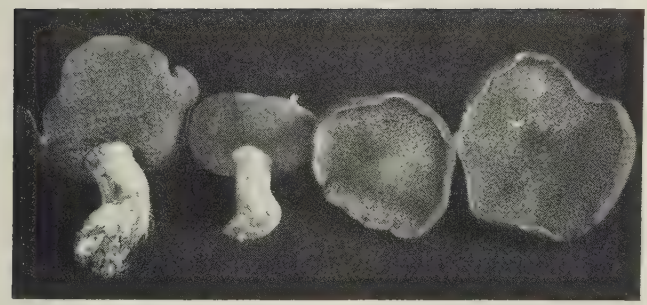
Gomphidius subroseus Kauffm. var. homobasis Sing.

A typo base stipitis haud vel vix flava differt; cum typo.

Gomphidius, subgenus Chroogomphus Sing. subgen. nov.

Carne plus minusve colorato, velo praesente, ex hyphis parallelis, incrustatis consistente; subhymenio irregulari-intermixto, densissimo; mediostrato haud distincto in adultis; mycorrhiza variis cum coniferis sed vix cum laricibus observata.

Harvard University
Cambridge, Massachusetts



Photograph by F. P. Sipe

Suillus ruber Singer & Sipe. × about $\frac{1}{3}$

A POSTGLACIAL FOSSIL FLORULA NEAR FORESTER, MICHIGAN *

GLADYS F. WEST

THE history of the postglacial predecessors of the present Great Lakes has been preserved by their old beaches and outlets as they passed through their successive stages of growth and development during the time of the recession of the Wisconsin ice sheet from northeastern United States and southeastern Canada. Since this history is intimately associated with the cutting of certain gorges in the Niagara River, the chronology of which has been carefully estimated, it is possible to approximate the ages of most of these lakes and likewise that of any organic remains preserved in their deposits.

Careful study and identification of the plant and animal remains from deposits which can be definitely correlated with any of the postglacial lake stages should eventually make possible a fairly complete picture of the development of vegetation and climate in the Great Lakes region since the retreat of the last ice sheet. So far the deposits of glacial Lake Chicago have received the most attention. Baker (1920) brought together the results obtained by earlier workers and by himself during many years' work and established a florula of 15 species and a fauna of 109 species from the deposits of the various stages of this lake. Recently the Two Creeks forest beds described by Goldthwait (1907) have been studied botanically in two different exposures by Wilson (1932, 1936). He considered these forest beds to have been formed during the Glenwood Stage of glacial Lake Chicago, and he described from both deposits forests composed almost entirely of spruce.

Remains of plants which lived during and after the time of glacial Lake Maumee, a correlative of glacial Lake Chicago, are being described by Hansen (1948), who outlines a gradual develop-

* Papers from the Department of Botany of the University of Michigan, No. 514.

ment of vegetation from the time of the first appearance of the northern coniferous trees in the region to the time of a mixed deciduous forest.

References to organisms that existed during the time of glacial Lake Algonquin are few and scattered. Hunter (1902) mentioned fossil unios, bones, and pieces of wood from a well boring in a deposit of glacial Lake Algonquin in Simcoe County, Ontario. Tarr (1904) referred to a deposit of logs and pieces of wood near Ithaca, New York, associated with glacial Lake Iroquois, a correlative of glacial Lake Algonquin. Penhallow (1905) identified part of the wood as *Pinus rigida* and *Larix americana*. West (1935) reported wood of *Fraxinus nigra* from a swamp deposit in glacial Lake Tonawanda in New York, a correlative of both Lake Iroquois and Lake Algonquin. Wilson's study (1944) of the sediments in Douglas Lake, Cheboygan County, Michigan, should give valuable chronological information on deposits formed during Algonquin and Nipissing time in that immediate locality.

In the Lake Superior region Wilson (1931, 1935) described plant remains from peat submerged fifty-four feet below the surface of the lake near Sand Island, off the north shore of Wisconsin. This deposit was formed during the time of the Nipissing Great Lakes, while the northern outlet at North Bay, Ontario, was in operation. The tree and shrub species represented were *Taxus canadensis*, *Pinus Strobus*, *P. Banksiana*, *P. resinosa*, *Larix laricina*, *Picea mariana*, *Salix sp.*, *Alnus sp.*, *Quercus sp.*, *Acer spicatum*, *Betula papyrifera*, *B. pumila*, and *Chamaedaphne calyculata*. Taylor (1931, pp. 265–267) has pointed out the importance of this deposit from the standpoint of lake history, since it "appears to supply the first reliable evidence bearing on the depth of submergence of the original Nipissing beach," which was caused by uplift of the land in the north.

Cooper and Foot (1932) described a deposit at Minneapolis, Minnesota, which was formed previous to the inauguration of glacial Lake Agassiz, and reported a florula of thirteen genera, which they described as a bog forest in the lowlands and a "climax forest of white spruce, balsam fir, white pine and birch" in the upland.

The present investigation[1] was undertaken in an effort to ob-

[1] For helpful suggestions and criticisms during the course of this study I am greatly indebted to Professor H. H. Bartlett. I am also under obligation to

tain as much information as possible on the vegetation and climatic conditions which existed during the last or highest stage of glacial Lake Algonquin.

The accumulation of more information of this type should also prove helpful in the interpretation of fossil remains from interglacial periods of the Pleistocene.

LOCATION AND DESCRIPTION OF THE FORESTER DEPOSIT

The Forester deposit is located in the southwest quarter of the southeast quarter of Section 28, Forester Township, Sanilac County, T. 13 N., R. 16 E., on the eastern side of the "Thumb" of Michigan, bordering on Lake Huron (Fig. 1). All the plant remains described in this paper were obtained from two exposures, one in the south bank of Big Creek about 365 yards inland from the lake shore, and the other in the north bank of the creek, ranging from 350 to 365 yards inland (Pl. I, Figs. 1–2).

The deposit rests on a mixture of blue-gray plastic clay, sand, and gravel extending down to the water level of the creek. The section in the north bank of Big Creek (Pl. I, Fig. 2) may be described as follows:

Strata	*Thickness of strata*
4. Surface soil composed of fine lake sand	1 ft. 8 in.
3. Grayish-tan lake clay	2½–3 ft.
2. Grayish-brown marly and peaty laminated clay	3–3½ ft.
1. Leaf bed composed of layers of leaves interbedded with layers of fine buff-colored silt	3–3½ ft.

At the time the collections were made some of the fossil leaves in Stratum 1 were weathered out of their matrix and were hanging in ragged masses from the side of the bank (Pl. II, Fig. 1). From their midst the end of a partially crushed sycamore trunk protruded (Pl. I, Fig. 2).

the late Dr. Frank Leverett for personally visiting the deposit and for much information concerning the geological history and development of it. My appreciation is expressed to Dr. W. C. Steere for the identification of the thirteen species of fossil mosses. Thanks are due to Mr. L. A. Harris for photographs and information concerning the location of the deposit; to Dr. E. A. Bessey for some of the seeds used for identification of the fossil specimens; and to the Michigan State Seed Laboratory for the privilege of using specimens in their seed herbarium. Grateful acknowledgment is made to Dr. Ethel B. Hansen for much assistance in the collection of the fossil material during the summers of 1931 and 1932.

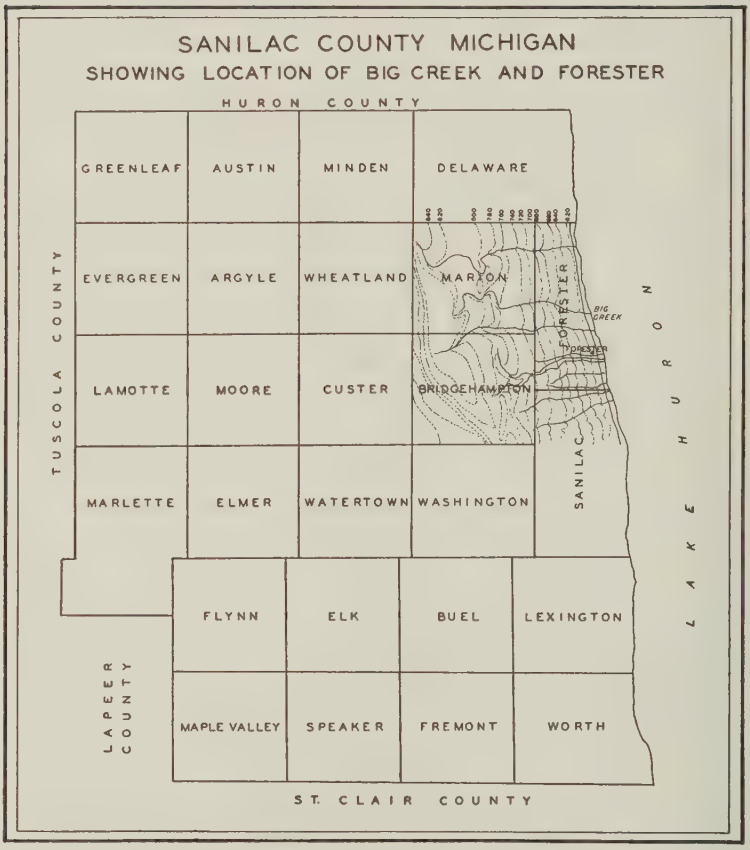


FIG. 1

(Based upon a map by C. H. Gordon, *Geological Report on Sanilac County, Michigan,* Geol. Surv. Mich., Vol. VII, Part 3)

GEOLOGICAL HISTORY AND DEVELOPMENT OF THE DEPOSIT

The history and development of the Forester deposit is so intimately associated with the history of certain of the Great Lakes that to give the history of one is to give the history of the other. It begins about thirty thousand years ago, when the Wisconsin

ice sheet began to retreat from northeastern United States. The early period of the recession of the ice front was characterized by a slow retreat to the southern watershed of the Great Lakes basins, where it assumed a lobate outline corresponding roughly with the lake basins. The melt waters were gathered into small lakes along the margins of the ice lobes, and were dammed up between the ice barrier and the higher land of the watershed. These small lakes, formed at different times and fed by the melting ice, developed into vast bodies of water of much greater magnitude than our present Great Lakes system (Leverett and Taylor, 1915, pp. 318–321).

The actual development of the Forester deposit began at the time when the margin of the continental ice sheet had retreated sufficiently for the glacial waters in the basins of Lake Superior, Lake Michigan, Lake Huron, and Georgian Bay to be free to unite into one vast body of water at one level, known as the Second or Kirkfield stage of Lake Algonquin (Leverett and Taylor, 1915, pp. 410–411). This lake drained through an outlet near Kirkfield, Ontario, eastward through the Trent Valley into glacial Lake Iroquois, which lay in the Lake Ontario basin (Leverett and Taylor, 1915, p. 412; Leverett, 1917, p. 137). By this time the channel of Big Creek at Forester was already in existence and flowing into Lake Algonquin (the late Dr. Leverett, personal communication). Perhaps more than half of postglacial time had already elapsed.

After the ice had almost entirely disappeared from the northern part of the lake basins a differential uplift of the land surface began in the Trent Valley, which resulted in a gradual rise of the Kirkfield outlet (Leverett and Taylor, 1915, pp. 329, 410). While the region around the northern outlet was being gradually tilted upward, the level of the land around the southern part of the lake remained stationary. The water was thus gradually shifted to the south and began to back up on higher land and submerged the Kirkfield beaches. With the gradual rise of water level in the south it became correspondingly lower in the north, until eventually the Kirkfield beaches were abandoned. South of a line running "from Kirkfield west-northwest, passing about 20 miles south of Sault Ste. Marie," the waters rose to a higher level on the land, and the beaches of the Kirkfield stage were submerged and destroyed (Leverett and Taylor, 1915, p. 413). North of this line they were abandoned,

and new beaches formed at a lower level. The two southern outlets at Chicago and Port Huron gradually came to receive more and more of the overflow. But for a long time all three outlets were in use during a transitional three-outlet stage. Eventually the northern outlet was totally abandoned, and the two southern outlets discharged the entire overflow. However, the Port Huron outlet, which was on a clay foundation, was rapidly cut down to a lower level than the Chicago outlet, which lay over a rock sill. The entire discharge then passed through Port Huron (Leverett and Taylor, 1915, pp. 410, 414; Leverett, 1917, p. 138), southward into Lake Erie and eventually into the Niagara River. This represents the last or highest stage of Lake Algonquin.

As a result of the uplift in the north, in the vicinity of Forester the waters rose to 607 feet above sea level, as is shown by the beach of the highest stage of Lake Algonquin. Accordingly, the waters had also backed up into the mouth and valley of Big Creek to a point 607 feet above sea level and formed an estuary.

The deposit at Forester is represented in two sections exposed by the present channel of Big Creek as it cut through the old silted-up estuary. The bottom of the exposure, composed of gravel, sand, and blue-gray plastic clay, probably represents the bed of the old creek channel, which was gradually submerged by the rising Algonquin waters.

The leaves in Stratum 1 (Pl. I, Fig. 2) appear to have been deposited during the early part of the uplift, while the estuary was being formed and the water was still shallow. They were probably blown into the creek and carried downstream, finally coming to rest at the mouth of the channel, where it emptied in the shallow water of the estuary. The presence of certain fossil remains (which will be described later) in Strata 2 and 3 above the leaf layer indicates a rise of several feet in water level of the estuary caused by the continued uplift in the north.

A further retreat of the ice in southern Canada uncovered a lower outlet at North Bay, Ontario, in the Mattawa Valley, which eventually came to receive all the overflow and resulted in the inauguration of the Nipissing Great Lakes (Leverett and Taylor, 1915, p. 330; Leverett, 1917, p. 138). The Nipissing Great Lakes endured until a differential uplift in the Mattawa Valley raised the level of the North Bay outlet sufficiently for the discharge to

be again shifted to the southern outlet at Port Huron, which resulted in the post-Nipissing or modern stage of the upper three Great Lakes.

At the close of Lake Algonquin the ice front probably stood ten to twenty-five miles north of Lake Superior, and north of the line of the Canadian Pacific Railway, which passes through Franz and Sudbury, Ontario, southeastward to Mattawa, Ontario, and thence eastward through southern Quebec (Antevs, 1931, pp. 13, 15), a distance of approximately 270 miles from Forester. At the inauguration of the second or Kirkfield stage the ice front, which stood near Kirkfield, Ontario, was approximately 210 miles distant from Forester. From that time until the close of the last or highest stage the ice front had receded approximately 60 miles. It can be reasonably estimated, therefore, that at the time of the formation of the estuary in Big Creek during the last stage of Lake Algonquin the ice front stood approximately 240 to 250 miles away from a forest growing in the valley of Big Creek, abundant remains of which have been buried and preserved in the silts of the estuary.

AGE OF THE DEPOSIT

The age of such a deposit is always a matter of considerable interest. As shown by measurements of the rate and the amount of recession of the Horseshoe Falls, the age of the Upper Great Gorge in the Niagara River may be about 4,000 years (Kindle and Taylor, 1914, p. 170; Taylor, 1929, p. 262; Dr. Leverett, personal communication). Since the Upper Great Gorge was formed after the drainage of the Nipissing Great Lakes was diverted from the Mattawa–Ottawa valleys back to the southern outlet at Port Huron, so that the discharge of the upper three Great Lakes and Lake Erie passed into the Niagara River (Kindle and Taylor, 1914, p. 154, fig. 14), the amount of time required to cut the Upper Great Gorge also represents the length of time during which the upper three Great Lakes discharged through the southern outlet. The northern outlet of the Nipissing Great Lakes has been estimated to have been in operation for from 2,000 to 2,500 years (Taylor, 1929, p. 260). The amount of erosion accomplished by the last or highest stage of glacial Lake Algonquin while it discharged to the south is so slight that it would probably not have taken over 4,000 years; and the length of time might be estimated to have been even less,

except for the fact that for a while the southern discharge was divided between two outlets, viz., Chicago and Port Huron (Dr. Leverett, personal communication). The deposit, the formation of which began in the early part of the last or highest stage of Lake Algonquin, may then be about 10,500 years old and is, therefore, of considerable antiquity.

CLASSIFICATION AND DESCRIPTION OF PLANT REMAINS

Thallophyta

CHARACEAE

Chara sp.

Cooper and Foot, 1932, pp. 69, 70; Baker, 1920, pp. 26, 94, 101.

Nutlike oögonia incrusted with calcium carbonate were present in large numbers in Strata 2 and 3. Their absence from Stratum 1 (the leaf bed) has been interpreted to mean that the deposition at that level was in very shallow water, and probably took place during the time when the water level of Lake Algonquin was slowly rising in the south and had begun to creep back into the channel of Big Creek.

Bryophyta

MacBride, 1896, pp. 63–66; Cheney, 1930, pp. 66–68; 1931, pp. 93, 94; Williams, 1930, p. 33; Cooper and Foot, 1932, pp. 63–72; Wilson, 1932, pp. 31–46; 1936, p. 320; Berry, 1933, 7; Voss, p. 1933, p. 813; Steere, 1941, pp. 83–89; Hansen, 1948, p. 53.

Remains of the vegetative structure of the following thirteen species of mosses, which were found in the leaf bed, were identified by Dr. W. C. Steere:

Aulacomniaceae
Aulacomnium heterostichum (Hedw.) Bry. Eur.
Leucodontaceae
Leucodon sciuroides (L.) Schwaegr. (Pl. III, Fig. 1)
Thuidiaceae
Anomodon attenuatus (Schreb.) Hüben. (Pl. III, Fig. 2)
Anomodon rostratus (Hedw.) Schreb.
Thuidium delicatulum (L.) Mitt. (Pl. II, Figs. 2–3)
Amblystegiaceae
Amblystegium varium (Hedw.) Lindb.
Campylium radicale (P. B.) Grout

Drepanocladus aduncus (Hedw.) Warnst.
Leptodictyum riparium (Hedw.) Warnst.
Brachytheciaceae
Bryhnia novae-angliae (Sull. and Lesq.) Grout
Eurhynchium strigosum (Hedw.) J. and S. (Pl. III, Figs. 3–4)
Plagiotheciaceae
Plagiothecium denticulatum (L.) Bry. Eur.
Hypnaceae
Hypnum imponens Hedw.

Of this group, *Anomodon attenuatus* (Schreb.) Hüben. was represented the most abundantly, and *Leucodon sciuroides* (L.) Schwaegr. ranked second in frequency of occurrence.

All these species are common in northeastern United States, and all are found in the present flora of Michigan. For the most part they represent species which can be found growing in a beech–maple forest on moist shaded banks of streams, on stones, and on tree trunks, with the exception of *Drepanocladus aduncus* (Hedw.) Warnst., which is aquatic, and *Leptodictyum riparium* (Hedw.) Warnst., which is subaquatic.

Pteridophyta

polypodiaceae

Onoclea sensibilis L. (Sensitive fern)

(Pl. IV, Fig. 1)

A small portion of a fertile frond, the pinnules of which still retain on their lower surfaces a few characteristic sporangia with spores, represents the only remains of this species. The sensitive fern is found abundantly in wet places throughout Michigan. The genus has not hitherto been reported in the Pleistocene of this country.

Spermatophyta

pinaceae

Pinus Strobus L. (White pine)

(Pl. IV, Fig. 7)

Safely, 1867, p. 116; Penhallow, 1896, p. 67; 1898, p. 526; Cooper and Foot, 1932, pp. 66, 69; Wilson, 1935, pp. 533–535; Hansen, 1948, p. 54.

The lower half of a single mature cone from Stratum 2 represents the only remains of this species.

White pine is found in Michigan throughout the Upper Peninsula

and as far south in the Lower Peninsula as Allegan, Eaton, and St. Clair counties, approximately fifty miles farther south than its occurrence as a fossil near Forester.

Pinus sp.

Pollen representing at least two species of pine was noted.

Larix laricina (DuRoi) Koch. (Tamarack)

Safely, 1867, p. 116; Keyes, 1893, p. 357; Dawson and Penhallow, 1890, p. 326; Penhallow, 1896, pp. 60, 61, 67, 69; 1898, pp. 526, 527; 1905, pp. 69–70; MacBride, 1896, pp. 65, 66; Calvin, 1898, p. 240; Coleman, 1899, pp. 35, 36; Tarr, 1904, pp. 78, 79; Baker, 1920, pp. 42, 71; Cooper and Foot, 1932, p. 69; Voss, 1933, p. 814; Wilson, 1935, pp. 533–535; Hansen, 1948, p. 54.

A single fragmentary twig bearing one short lateral branchlet was found in the lower part of Stratum 2. The specimen has been arbitrarily assigned to *Larix laricina*, the only species native to northeastern United States, since there was no distinctive character present which would definitely mark it as this particular species and since the facies of the fossil florula resembles so closely that of the present in many parts of the Lower Peninsula of Michigan.

Tamarack is common in swampy areas throughout Michigan.

Picea sp. (Spruce)

Spruce is represented by pollen only. Although it has not been possible definitely to identify the species to which it belongs, it seems probable that it may represent *Picea mariana* (Mill.) BSP., from a swampy area near by.

Tsuga canadensis (L.) Carr. (Hemlock)

(Pl. IV, Figs. 2–4)

Hemlock was one of the most commonly represented species. Small twigs, needles, cones, and seeds were abundant in Strata 1 and 2. Tsuga pollen, undoubtedly referable to this species, was also found.

Hemlock occurs throughout Michigan today except in the southeastern part of the Lower Peninsula, where it extends as far south as Port Huron (Quick, 1923) along the eastern side.

Thuja occidentalis L. (Arbor vitae)

(Pl. IV, Figs. 5–6)

Dawson and Penhallow, 1890, pp. 324, 325; Wegeman, 1909, pp. 26, 27; Baker, 1920, pp. 42, 71, 101.

This species is sparingly represented in Strata 1 and 2 by small twigs with leaves, two mature open cones, and a few seeds.

Arbor vitae is common in low situations throughout the northern two thirds of Michigan; it extends as far south as Montcalm and Sanilac counties. According to Dodge (1912, p. 37), it is plentiful near the Lake Huron shore as far south as St. Clair County.

TYPHACEAE

Typha sp. (Cattail flag)

Penhallow, 1896, p. 64.

The genus Typha is represented by pollen only, and the species was not determined.

SPARGANIACEAE

Sparganium sp. (Bur reed)

(Pl. IV, Fig. 8)

Berry, 1914, p. 160; 1924, p. 16.

Achenes representing at least two different species were found abundantly in Stratum 2.

NAJADACEAE

Potamogeton sp. (Pondweed)

(Pl. IV, Figs. 9, 11)

Dawson and Penhallow, 1890, pp. 327, 331; Knowlton, 1896, p. 371; Penhallow, 1896, pp. 65, 66; 1898, p. 528; Coleman, 1915, p. 247; Baker, 1920, pp. 27, 39, 91; Hollick, 1931, pp. 37–39, pl. 2; Cooper and Foot, 1932, p. 69.

This genus is represented by a great many well-preserved achenes, representing at least three different species, found in Strata 2 and 3. Their presence in these two strata, along with remains of Chara and Myriophyllum, would seem to indicate a water depth of four or five feet or even more during the time of deposition. Their absence from Stratum 1 (the leaf bed) has, therefore, been interpreted to mean shallower water at that level.

ALISMACEAE

Sagittaria latifolia Willd. (Arrowhead)

(Pl. V, Fig. 1)

Achenes of *Sagittaria latifolia* were very common in Strata 2 and 3. In the present flora it is abundant throughout Michigan in wet places. This is the first reported occurrence of the genus in the Pleistocene of this country.

Alisma Plantago-aquatica L. (Water plantain)

This species is represented by a small number of achenes in Stratum 2. At the present time it is common and abundant in shallow water and ditches throughout Michigan. The presence of water plantain has not previously been reported in the Pleistocene of this country.

CYPERACEAE

Dulichium arundinaceum (L.) Britton

(Pl. V, Fig. 2)

Berry, 1924, p. 18, pl. I, figs. 17–18.

Two achenes represent the only remains of *Dulichium arundinaceum*. It is found abundantly in the present flora of Michigan in wet swampy places on the borders of streams, ponds, and small lakes.

Eleocharis olivacea Torr. (?) (Spike rush)

Small black achenes 1.25 mm. long, 0.75 mm. wide, obovate, with fragmentary tubercle, and bristles absent, resembling very closely *Eleocharis olivacea*, were present in considerable numbers in Strata 2 and 3.

This species has been found in both the Upper and the Lower peninsulas of Michigan, but it appears to be rather rare in the state.

No previous discovery of the gross remains of the genus Eleocharis has been recorded in the Pleistocene of this country.

Carex lupulina Muhl. (Sedge)

(Pl. V, Fig. 3)

Well-preserved achenes were found in Strata 2 and 3, which corresponded so closely with those of *Carex lupulina* that the de-

termination has been made without hesitation. In the present flora it is of common occurrence in swamps and wet places throughout Michigan.

Although Carex has been reported from both early and late Pleistocene deposits in this country, there is no previous record of this species.

Carex retrorsa Schwein.

(Pl. V, Fig. 4)

Hansen, 1948, p. 56.

Triangular-fusiform achenes resembling so closely the achenes of *Carex retrorsa* that it seems unquestionable that they belong to this species. It is one of the commonest sedges in Michigan.

Carex Schweinitzii Dewey (?)

(Pl. V, Fig. 5)

Achenes obovoid; equally 3-angled; 1.75 mm. long; styles fragmentary; perigynium incomplete, 3.5 mm. long; 1.5 mm. wide; few-nerved and very delicate. These achenes resemble more closely the achenes of *Carex Schweinitzii* than those of any other American species in the genus.

The species is not abundant in Michigan, and has been reported from only three counties in the Lower Peninsula, viz., Crawford (Beal, 1904, p. 57), Cheboygan (Gates and Ehlers, 1924, p. 212), and Ottawa (herbarium specimen in the University of Michigan Herbarium).

No previous occurrence of the species has been reported from the Pleistocene of this country.

SALICACEAE

Salix sp. (Willow)

The presence of Salix is represented by pollen alone. More than one species appears to be present. In all probability they grew in close proximity to the place of deposition.

There are a number of references to the occurrence of Salix during postglacial time, as well as earlier in the Pleistocene.

JUGLANDACEAE

Carya sp. (Hickory)

The only remains of this genus thus far found are deposits of pollen. The nature of the fossil florula is such as would indicate that hickory grew in a dry upland area some distance away from the place of deposition.

Several different species of hickory have been reported from the Pleistocene of this country.

BETULACEAE

Pollen representing certain members of the Betulaceae was found to be relatively abundant.

Carpinus caroliniana Walt. (Blue beech)

(Pl. VI, Figs. 6–9)

Berry, 1907a, p. 692; 1907b, pp. 340–341; 1910, p. 395; 1926, p. 108.

Remains of the blue beech were common in Strata 1 and 2 in the form of practically skeletonized leaves, bractlets, and a great many flattened nuts.

In Michigan blue beech occurs locally along streams and in wet places and is found most frequently in the southern part of the state.

Betula sp. (Birch)

Penhallow, 1896, p. 66.

A few seeds resembling very closely both *Betula lutea* Michx. f. and *Betula lenta* L. were found in Strata 1 and 2. There seems to be a sufficient amount of variation in the seeds of these two modern species to make an exact specific identification questionable. The composition of the fossil florula is such as to indicate the possible presence of both. Both species, although occurring throughout the state, are most common in the northern part.

Betula alba L. var. *papyrifera* (Marsh.) Spach.

Safely, 1867, p. 116; Emerson, 1898a, p. 740; 1898b, p. 7; 1917, p. 148; Cooper and Foot, 1932, p. 69; Wilson, 1935, pp. 533–535.

This species is represented by a single seed, small cylinders of bark, and a few pieces of wood. The seed is unquestionably that

of *Betula alba* L. var. *papyrifera*, since the shape, size, and cell structure of the wings correspond identically with those features in this particular species and variety.

Although the wood structure was found to resemble very closely that of the paper birch, the identification is given with some hesitation, since certain of the diagnostic characters have been obscured as a result of decomposition and crushing.

Paper birch in Michigan occurs from Lansing northward, although Dodge (1912, p. 31) found it quite common a little farther south along the Lake Huron shore in St. Clair County.

FAGACEAE

Fagus grandifolia Ehrhardt (Beech)

(Pl. VII, Figs. 1–8; Pl. VIII, Figs. 1–4)

Orton, 1873, pp. 427–428; Knowlton, 1896, p. 371; Mercer, 1899, pp. 279, 281; Emerson, 1898a, p. 740; 1898b, p. 7; 1917, p. 148; Hollick, 1906, p. 226; Berry, 1906, pp. 88–89; 1907a, pp. 692–693, pl. 2, fig. 7; 1907b, p. 341; 1909, p. 435; 1910, pp. 393–394; 1914, p. 162; 1915, pp. 206–207; 1926, p. 108, pl. 48, figs. 3–13; 1927, p. 25; 1933, p. 11; Baker, 1920, p. 312.

Beech was the most common member of the fossil florula, and was represented by a large number of well-preserved leaves, bud scales, flattened burs and nuts, a small twig bearing a terminal bud, a single specimen of wood, and pollen. Leaves of this species were more abundant than those of any other species and, along with leaves of *Acer saccharum*, formed 85 per cent or more of the leaf bed. The pollen can be referred to this species with little doubt.

The wood structure was well preserved and corresponds identically with that of the modern beech (Brown and Panshin, 1940, pp. 446–448; Record, 1934, pp. 131, 132). Since published descriptions of Pleistocene wood are few, it has been thought advisable to describe the structure of some of the wood from this deposit.

Transverse section. — Annual rings 1.0 to 1.25 mm. wide. Diffuse-porous. Vessels angular to round or oval. Fibers still retain their shape, but in many specimens the secondary wall has disorganized, so that only the thin primary wall remains.

Radial section. — Vessel segments rather long; without spirals; end walls oblique, with perforations scalariform to simple; tyloses abundant. Rays heterogeneous.

Tangential section. — Tyloses present a thin platelike appearance. Rays short-uniseriate to large compound structures.

Beech occurs throughout Michigan, but is more abundant in the Lower Peninsula, and is a prominent member of the climax forest in the locality where the fossil material was collected.

Quercus sp. (Oak)

The only remains of this genus thus far found in the deposit consist of pollen. The complete absence of any other remains of oak indicates that it probably was not a component part of the vegetation along the creek, but grew in a higher, drier upland area some distance away from the place of deposition.

There are many references to the occurrence of Quercus during postglacial time as well as throughout the Pleistocene.

URTICACEAE

Ulmus americana L. (American elm)

(PL. IX, Figs. 1–4)

Penhallow, 1896, p. 68; 1898, p. 528; 1907, pp. 449, 450; Berry, 1915, p. 207.

This species is represented by a large number of leaves and fifteen identified specimens of wood from Strata 1 and 2. Although no complete specimens of leaves were obtained, it was possible to distinguish them from *Ulmus fulva* Michx. by means of the venation.

Excluding the effects of disintegration, the wood structure corresponds exactly with that of the modern species (Record, 1934, pp. 120–121, pl. 3, fig. 2; Brown and Panshin, 1940, pp. 462–464).

Transverse section. — Annual rings variable in width, 0.25 to 1.5 mm., and usually visible to the unaided eye. Ring porous. Vessels of spring wood large, oval, elliptical to slitlike, and, with few exceptions, arranged in a single tangential row. Summer wood vessels irregularly angular; arranged for the most part in wavy tangential bands. Tyloses present in both early and late vessels. Wood parenchyma vasicentric, scarcely distinguishable in poorly preserved specimens; in better-preserved specimens distinguishable by brownish contents; shape usually distorted. Fibers arranged in bands alternating with the bands of summer vessels. The fibers seem to have undergone the greatest amount of decomposition. In only a few specimens were the outlines of individual fiber cells dis-

tinguishable. In some the primary wall was distorted, and the secondary wall was present in the form of a small irregular mass lying to one side of the cell; in others the secondary wall had entirely disappeared. Rays 1 to 6 cells wide.

Radial section. Vessel segments short; tertiary spiral thickenings still present in some of the summer vessels; end walls horizontal to oblique; perforations simple. Tyloses abundant. Wood parenchyma arranged in vertical strands of 2 to 6 cells. Rays homogeneous.

Tangential section. Rays range from short, uniseriate to multiseriate structures 2 to 6 cells wide, and 9 to 40 or more cells high. Ray cells distorted because of radial crushing.

In the present flora white elm is common throughout Michigan.

Ulmus sp.

Pollen representing one or more species of elm was found to be relatively abundant. Both *Ulmus americana* and *U. fulva* were probably represented.

Laportea canadensis (L.) Gaud. (Wood nettle)

(Pl. X, Figs. 11–13)

Characteristic achenes of wood nettle were common in the leaf bed. This species occurs throughout Michigan, but appears to be more common in the southern part of the state (Quick, 1923, p. 226).

It has not previously been reported from the Pleistocene of North America.

Boehmeria cylindrica (L.) Sw. (False nettle)

A single achene found in the leaf bed represents the only remains of *Boehmeria cylindrica*. In the present flora of Michigan it is found only in the Lower Peninsula.

There has not been a previous report of the occurrence of the genus in the Pleistocene of this country.

POLYGONACEAE

Polygonum acre HBK. (Water smartweed)

The characteristic black shining achenes of *Polygonum acre* were found occasionally in Stratum 2. In Michigan, water smart-

weed inhabits swamps and wet places throughout the state, but it occurs more abundantly in the Lower Peninsula.

Although the genus has been reported previously from the Pleistocene of the United States, this represents the first occurrence of *Polygonum acre.*

RANUNCULACEAE

Ranunculus septentrionalis Poir. (Swamp buttercup)

Emerson, 1898b, p. 7; 1917, p. 148; Berry, 1924, pp. 20, 24; 1933, pp. 15–17.

Flat, margined achenes with fragmentary styles were frequent in Strata 1 and 2. Swamp buttercup is common throughout Michigan.

The genus has been reported previously from the Pleistocene of this country, but this is the first record of *Ranunculus septentrionalis.*

Ranunculus recurvatus Poir.

(Pl. V, Fig. 6)

A single achene 2.75 mm. long by 2 mm. wide, flat, with a somewhat fragmentary style, was found in Stratum 1. Although the fossil specimen resembles very closely achenes of *Ranunculus recurvatus* Poir., the final identification was made on the basis of the cell structure, which seems to resemble that of this species more closely than that of any other. In the present flora the species is common throughout Michigan.

It has not been previously reported from the Pleistocene of this country.

Anemone sp.

(Pl. V, Fig. 7)

A single achene, flat, smooth, with style somewhat fragmentary, was found in Stratum 2. The shape, size, and cell structure of this specimen resemble very closely these features in both *Anemone virginiana* Walt. and *A. cylindrica* Gray. The nature of the fossil florula is such as to indicate that the habitat conditions around the place of deposition were probably more suitable for *Anemone virginiana* than for *A. cylindrica.* Both species appear to be more frequent in the Lower Peninsula of Michigan than in the Upper Peninsula.

This is the first reported occurrence of the genus in the Pleistocene of this country.

PLATANACEAE

Platanus occidentalis L. (Sycamore)

(Pl. XI, Figs. 1–3; Pl. XII, Figs. 1, 3)

Knowlton, 1896, p. 371; Penhallow, 1896, p. 68; 1898, p. 526; 1907, p. 448; Mercer, 1899, p. 277; Emerson, 1898a, p. 739; 1898b, p. 7; 1917, p. 148; Berry, 1907a, pp. 695, 696; 1907b, p. 344; 1910, p. 397; 1914, p. 161; 1915, pp. 207–208; 1926, p. 112; 1933, pp. 11–12.

This species is represented by a great many leaves, a few seeds, a large log, and several smaller pieces of wood. Because of the large size of the leaves it proved to be impossible to secure unbroken specimens. Petioles with the characteristic large hollow base and detached from the leaf blades were frequent. The log (Pl. I, Fig. 2) measured 28 inches in diameter, and 109 annual rings were counted.

Although the original appearance of the wood was changed considerably because of crushing and decomposition, most of the diagnostic characters were present (Record, 1934, pp. 130–131; Brown and Panshin, 1940, pp. 482–483).

Transverse section. — Annual rings 2 to 4 mm. wide. Diffuse-porous. Vessels narrowly elliptical to slitlike, a shape caused by radial crushing of the log. Wood parenchyma diffuse; shape of individual cells distorted. Ray cells have abundant reddish-brown contents.

Radial section. — Vessel segments short; without spirals; end walls usually oblique; perforations simple or scalariform; horizontal full-bordered pits; tyloses abundant. Rays homogeneous.

Tangential section. — Vessels radially crushed. Rays broad; 8 to 14 cells wide and 6 to 7 times as high. Ray cells distorted because of radial crushing. Wood parenchyma and wood fibers practically indistinguishable; pitting obscure.

Along the eastern side of Michigan the northern limit of sycamore is the Saginaw Bay region (Dodge, 1911, p. 96; 1921a, p. 195). In the central part of the state it is reported as far north as Roscommon County (Illick, 1927, p. 61).

ROSACEAE

Crataegus sp. (Hawthorn)

(Pl. XII, Fig. 2)

A single incomplete specimen of a leaf, 2.25 inches long by 1.25 inches wide; serrate-dentate, and appears to have been entire

and cuneate at the base, and acute or rounded at the apex. There is some similarity to leaves of *Crataegus Crus-galli* L.

The genus has been reported a number of times from the Pleistocene of this country.

Rubus idaeus L. (?)

(Pl. X, Fig. 3)

Seeds irregularly bean-shaped; 2 to 2.5 mm. long; 1 mm. wide; somewhat flattened; coarsely and irregularly reticulate-ridged; raphe conspicuous; seeds sometimes hollow and somewhat shriveled. The seeds resemble very closely those of *Rubus idaeus* L., although they are somewhat smaller than those of either the species or the variety *aculeatissimus* [C. A. Mey.] Regel & Tiling, which is common in Michigan. It is quite possible, however, that *Rubus idaeus* L. or some form of it is represented. Both *R. idaeus* and the variety *aculeatissimus* are common throughout Michigan.

Although this genus has been reported previously from the Pleistocene of this country, no specific identifications have been made.

Rubus allegheniensis Porter (?)

(Pl. X, Fig. 4)

Hansen, 1948, p. 58.

This identification was made on the basis of two seeds. Seeds broadly ovoid, 1.75 to 2 mm. long; 1.25 to 1.5 mm. wide; somewhat compressed; coarsely and irregularly reticulate-ridged, with a conspicuous margin extending around them from hilum to end of the raphe; raphe conspicuous. These specimens unquestionably belong in the blackberry group and resemble *Rubus alleghe-niensis* Porter in every respect except size, since they are slightly smaller. This species also is common throughout Michigan.

Agrimonia sp. (Agrimony)

(Pl. X, Figs. 8–9)

Three fruits, found in Stratum 2, were 3.75 mm. long by 3.25 mm. wide; flattened; bristles absent from the marginal rim; conspicuous longitudinal ridges present which are characteristic of the fruits of Agrimonia. Sufficient diagnostic characters were not present to make possible a specific identification.

The genus has not hitherto been reported from the Pleistocene of North America.

RUTACEAE

Zanthoxylum americanum Mill. (Prickly ash)
(Pl. X, Figs. 7, 10)

Hansen, 1948, p. 58.

A few seeds and a great many characteristic thorns were found in Strata 1 and 2. Prickly ash occurs in the Lower Peninsula of Michigan and is characteristic of the shrub zone in the beech–maple climax association.

ACERACEAE

Acer saccharum Marsh. (Sugar maple)
(Pl. XIII, Figs. 1–3; Pl. XIV)

Dawson and Penhallow, 1890, pp. 329–330; Emerson, 1898a, p. 739; 1898b, p. 7; 1917, p. 148.

The sugar maple, one of the commonest members of the fossil florula, was represented by leaves, seeds, and wood. The leaves of this species were the second most abundant and, along with those of beech, made up 85 per cent or more of the leaf bed (Stratum 1).

The seeds were flattened, with the wings either fragmentary or entirely absent. The wood was poorly preserved, and all the necessary diagnostic characters (Record, 1934, pp. 128–129; Brown and Panshin, 1940, pp. 494–496) were recognized only after sectioning several pieces.

Transverse section. — Annual rings 1.0 to 1.4 mm. wide. Diffuse-porous. Vessels oval, narrowly elliptical to slitlike; single, or in radial rows of 2 to 6; vessel walls partially to entirely disintegrated. Brown gummy substance frequent in vessels, or in the spaces left after decomposition of the vessels. Fibers mostly collapsed.

Radial section. — Vessel segments short; spirals distinguishable in some vessels; end walls oblique; perforations simple. Gummy deposits in the form of horizontal plates or round masses present in the vessels, as in modern wood, but more abundant. In the disintegrated vessels the gummy deposits often formed casts showing the impression of the spirals. Rays homogeneous.

Tangential section. — Rays varying from short-uniseriate to large

structures 7 or 8 cells wide and 80 or more cells high. Pitting on fibers obscure.

In the present flora sugar maple is found throughout Michigan.

Acer saccharum var. *Rugelii* Rehd. (?)

(Pl. XV, Figs. 1–2)

A large leaf differing from those of *Acer saccharum* Marsh. in that it is 3-lobed and 3-veined, with an entire to slightly undulated margin, has been found to resemble very closely *Acer saccharum* var. *Rugelii* Rehd., as described by Sargent (1926). The long slender lateral lobe of the fossil specimen agrees better with the description of variety *Rugelii* than with that of variety *nigrum* which, on the whole, has much broader and shorter lobes.

Another leaf (Pl. XV, Fig. 2), also representing some form of these species, although fragmentary, was found to resemble closely the base of a small leaf of variety *Rugelii*. However, in view of the fact that a great deal of natural variation is found in the leaves of *A. saccharum*, all that can be said with certainty is that these leaves represent variations of the species named above.

Variety *Rugelii*, according to Sargent (1926), may extend as far north as the Southern Peninsula of Michigan and southern Ontario. Although it does not appear in any published reports on the flora of Michigan, herbarium specimens of it that were collected at Port Huron and Isle Royale are in the herbarium at the University of Michigan.

Acer sp.

Pollen representing members of this genus was relatively abundant.

VITACEAE

Vitis vulpina L. (River-bank grape)

(Pl. X, Fig. 5)

Hansen, 1948, p. 58.

A single seed from Stratum 1 has been referred to this species. There are many reports of the occurrence of grape in both interglacial and postglacial periods, but only a few specific identifications have been certainly made.

TILIACEAE

Tilia americana L. (Basswood)

(Pl. VI, Figs. 1–5)

Penhallow, 1898, p. 528; 1907, p. 449.

Basswood is represented in the leaf bed by a number of leaf fragments and a great many bracts and fruits. The leaf specimens were referred to *Tilia americana* L. on the basis of the coarse, deep serration of the margin, the long incurved points of the teeth, and the long slender, abruptly acute apex. The bracts resembled those of this species more closely in general shape and size than those of any other species of the genus native to this country.

Tilia americana is found throughout Michigan.

HALORAGIDACEAE

Myriophyllum sp. (Water milfoil)

(Pl. IV, Fig. 10)

A number of small pectinate-pinnatifid floral leaves, 3 to 5.5 mm. long, referable to some species of Myriophyllum, were found in Stratum 3. There was no indication of their presence in the two lower strata.

The genus has not previously been reported from the Pleistocene.

CORNACEAE

Cornus stolonifera Michx. (Red-osier dogwood)

(Pl. V, Figs. 8–9)

A small number of seeds characteristic of this species were found in the leaf bed; also a few small, undeveloped fruits of some species of dogwood. The red-osier dogwood is common throughout Michigan.

The genus has been reported a number of times in the Pleistocene of this country, but this is the first record of *Cornus stolonifera* Michx.

Nyssa sylvatica Marsh. (Black gum)

(Pl. VII, Fig. 9)

Berry, 1933, p. 22.

A single rather fragmentary leaf, simple, obovate, 1.875 inches long, 0.875 inch wide, entire, tip acute; base appears to be cuneate.

In shape, size, and details of minute venation it corresponds so closely with small leaves of this species that, although it is fragmentary, the determination was made without hesitation.

In Michigan black gum is frequent in the southern half of the Lower Peninsula and extends as far north as Manistee on the Lake Michigan side (Otis, 1925; Illick, 1927). On the Lake Huron side of the state it extends as far north as Omer, in Arenac County (Dodge, 1921b, p. 17). The northern limit of *Nyssa sylvatica* in Michigan today is only about sixty miles north of the place where it grew about ten thousand years ago.

OLEACEAE

Fraxinus sp. (Ash)

(Pl. XVI, Figs. 1–2, 4)

Penhallow, 1898, pp. 525–529; 1900, pp. 334–339.

Fragmentary leaflets referable to this genus were abundant in the leaf bed. On the basis of shape, size, and, more especially, character of the margin and venation, these specimens resemble more closely leaflets of *Fraxinus americana* L. and *F. pennsylvanica* Marsh. than those of any other species. No diagnostic character was found which could be used to determine definitely which one of the two species was represented. The nature of the fossil florula indicates a beech–maple climax forest, and since *F. americana* is considered an abundant dominant in the beech–maple climax forest of the Lower Peninsula, with *F. pennsylvanica* present in the lowland areas (Quick, 1923, pp. 223–232), it is altogether possible that both species may be represented by these fossil specimens.

The Fraxinus pollen found may represent more than one species. *Fraxinus americana* is common throughout Michigan, whereas *F. pennsylvanica* is found chiefly in the southern part of the Lower Peninsula.

Fraxinus nigra Marsh. (Black ash)

(Pl. XVI, Fig. 3)

Penhallow, 1898, pp. 527, 528; West, 1935, pp. 20–22, pl. 324, figs. 1–4; Hansen, 1948, p. 59.

A single specimen of wood from the south bank of the creek represents the only remains of black ash. Although poorly pre-

served, its structure corresponds with that of the wood of the modern species (Record, 1934, p. 124, pl. 5, fig. 2; Brown and Panshin, 1940, pp. 518–519).

Transverse section. — Annual rings 0.5 to 0.75 mm. wide. Ring porous. Spring vessels irregularly oval, narrowly elliptical to slitlike; arranged singly or in radial groups of two. Shriveled tyloses sometimes visible. Summer wood vessels relatively large, isolated, or in radial rows of two or three, and surrounded by wood parenchyma, which has usually not undergone as much decomposition as the fibers. The masses of parenchyma surrounding the summer wood vessels do not ever appear to be connected. Rays difficult to distinguish and study.

Radial section. — Vessel segments short; without spirals; end walls transverse to oblique; perforations exclusively simple. Rays homogeneous. A golden brown gummy substance was sometimes present in the vessels and is undoubtedly a decomposition product.

Tangential section. — Rays distorted as a result of crushing; 1 to 3 cells wide, with the majority of them biseriate; 3 to 16 cells high. Difficult to distinguish individual fibers because of decomposition and collapse of the walls.

In the present flora black ash is found throughout Michigan; it becomes more important in the northern part of the state.

CAPRIFOLIACEAE

Sambucus canadensis L. (Common elder)

(Pl. X, Fig. 1)

Berry, 1924, p. 20; 1933, pp. 22, 23; Hansen, 1948, p. 59.

Nutlets of the common elder were found to be very abundant in Strata 1, 2, and 3.

This species is common throughout Michigan and abundant in the locality where the fossil collection was made.

Sambucus racemosa L. (Red-berried elder)

(Pl. X, Fig. 2)

Hansen, 1948, p. 59.

Seeds of this species were distinguished from those of *Sambucus canadensis* because the surface is less rough and is composed of tiny wavy ridges, which are for the most part horizontal and parallel.

Sambucus racemosa is found throughout Michigan, but most abundantly in the northern part.

COMPOSITAE

Bidens frondosa L. (Beggar-ticks)

(Pl. X, Fig. 6)

Berry, 1933, p. 23.

A number of achenes characteristic of this species were found in the leaf bed. Achenes 8 mm. long by 3 mm. wide; obovate-cuneate; flat; 1-nerved on either face; 2-awned; awns retrorsely barbed; only fragmentary remains of hairs present on the margins of achenes.

Bidens frondosa L. is of common occurrence throughout Michigan.

Bidens laevis (L.) BSP.

Four achenes belonging to this species were found in the leaf bed. Achenes 6 to 7 mm. long; wedge-shaped; many-nerved; 4-awned; awns retrorsely barbed; retrorsely hispid on the margins of the achenes.

In Michigan this species has been reported only in the southern part of the Lower Peninsula, where it has been found in St. Clair County (specimen in the University of Michigan Herbarium), Tuscola County (Dodge, 1921a, p. 220), Huron County (Dodge, 1911, p. 118), and the Grand Rapids region.

Bidens cernua L. (?)

Achene 5 mm. long; wedge-obovate; many-nerved; fragmentary remains of four awns. This specimen resembles *Bidens laevis* (L.) BSP. very closely except that it appears to have been dilated at the tip and to have been 4-angled, as in *B. cernua*. The fragmentary awns appear to have been retrorsely barbed. Since the single specimen is incomplete, the specific identity remains questionable. *B. cernua* L. is of frequent occurrence throughout the state.

A RECONSTRUCTION OF THE FOSSIL FLORULA

At the beginning of the last or highest stage of glacial Lake Algonquin a climax forest of beech and maple flourished in the valley of Big Creek a short distance inland from the lake. Abundant

evidence of this was afforded by the thick leaf bed in Stratum 1, which was deposited during the early part of the uplift in the north. Eighty-five per cent of the deciduous leaves were found to be beech, *Fagus grandifolia* Ehrh., and sugar maple, *Acer saccharum* Marsh. Beech was represented by the greatest variety of remains, comprising leaves, seeds, fruits, bud scales, twigs, and wood, which would seem to indicate its dominance in the number of individuals. Sugar maple, represented abundantly by leaves and wood, appeared to be codominant with the beech. In all probability these two trees formed a dense, shady forest in the valley of Big Creek.

Hemlock, *Tsuga canadensis* (L.) Carr., ranked third in abundance of fossil remains. Many needles, cones, and seeds were present throughout the leaf bed and Strata 2 and 3. The abundance of hemlock remains and the fact that it is a shade-tolerant tree suggest that it was an important constituent of the forest at that time. At the present time hemlock occurs in the Lower Peninsula of Michigan in the northern consocies of the beech–maple climax association but extends south on both sides of the peninsula. On the eastern side along Lake Huron it occurs south of Forester about as far as Port Huron (Quick, 1923, p. 225).

Other important components of the forest were the American elm, *Ulmus americana* L., ash, either *Fraxinus americana* L. or *F. pennsylvanica* Marsh., or possibly both, sycamore, *Platanus occidentalis* L., and basswood, *Tilia americana* L., arranged in the order of the abundance of their fossil remains. Black birch, *Betula lenta* L., or yellow birch, *Betula lutea* Michx. f., or perhaps both, may have been present in greater numbers than the scant fossil remains suggest.

Other less important members of the forest were black ash, *Fraxinus nigra* Marsh., black gum, *Nyssa sylvatica* Marsh., hawthorn, *Crataegus sp.*, and a form of *Acer saccharum* Marsh., the leaves of which resemble those of variety *Rugelii.*

The shrubs associated with this forest were the common elder, *Sambucus canadensis* L., blue beech, *Carpinus caroliniana* Walt., prickly ash, *Zanthoxylum americanum* Mill., red-osier dogwood, *Cornus stolonifera* Michx., red raspberry, *Rubus idaeus* L., a blackberry closely resembling *Rubus allegheniensis* Porter, and the red-berried elder, *Sambucus racemosa* L. *Sambucus canadensis* L. is the most abundant shrub at the present time in the beech–maple

climax association in this particular area (Quick, 1923, p. 228). Among the fossil shrubs this species also ranked first in quantity of remains, and *Carpinus caroliniana* Walt. ranked second.

In the herbaceous layer hooked crowfoot, *Ranunculus recurvatus* Poir., is the only representative of the vernal vegetation. The summer aspect of the flora showed anemone, either *Anemone cylindrica* Gray or *A. virginiana* L., swamp buttercup, *Ranunculus septentrionalis* Poir., and agrimony, *Agrimonia sp.*, near the margin of the woods, and false nettle, *Boehmeria cylindrica* (L.) Sw., and wood nettle, *Laportea canadensis* (L.) Gaud., in the deep shade of the forest. The late summer and autumnal aspect of the herbaceous layer is indicated by the remains of water smartweed, *Polygonum acre* HBK., and the bur marigolds, *Bidens cernua* L., *B. frondosa* L., and *B. laevis* (L.) BSP.

Paper birch, *Betula alba* L. var. *papyrifera* (Marsh.) Spach., although not a member of the climax forest, was present in small numbers and probably grew somewhere near by in a drier situation along the sandy lake shore, as it does today.

In Strata 2 and 3, just above the leaf bed remains of *Chara sp.*, *Potamogeton sp.*, *Myriophyllum sp.*, and shells provide evidence of a rising water level in the mouth of Big Creek as a result of continued uplift of the land in the north. These two upper layers contained abundant remains of aquatic plants which grew in the mud and shallow water at the edge of the creek and estuary. They included water plantain, *Alisma Plantago-aquatica* L., spike rush, *Eleocharis olivacea* Torr., arrowhead, *Sagittaria latifolia* Willd., one of the bur reeds, *Sparganium sp.*, *Dulichium arundinaceum* (L.) Britton, and the sedges, *Carex lupulina* Muhl., *C. retrorsa* Schwein., and another which resembled in detail *C. Schweinitzii* Dewey, and a cattail, *Typha sp.* Remains of *Larix laricina* (DuRoi) Koch and *Thuja occidentalis* L. indicate swamp conditions around the estuary.

Among the species represented by macroscopic remains recovered from this old estuary only one, *Pinus Strobus* L., was characteristic of drier upland conditions. The small amount of pollen obtained from the silts of Strata 1, 2, and 3 indicate, in addition to the mesophytic forest along the creek, a drier upland habitat in which were *Quercus sp.*, *Carya sp.*, and two different species of Pinus.

It can be inferred that the area inhabited by plants the remains

of which were preserved in the silts of the old estuary was rather limited, and was probably confined to a narrow strip of land along the lake which is characterized by fertile lake clay. Back of this, in the upland, is an area characterized by a poorer type of soil formed by ground moraines and till plains, with boggy areas in the low places (Leverett and Taylor, 1915, pl. 7). The climax type of forest may have been scarce or absent in this region, which may have been covered with a forest predominating in oak and hickory, with white pine present as a relict of the earlier pine hemlock forest.

CLIMATIC SIGNIFICANCE OF THE FOSSIL FLORULA

According to Antevs' estimated temperature changes during postglacial time, the temperature during the life of Lake Algonquin was lower than that prevailing today in Michigan (Antevs, 1931, pp. 2 15). No evidence has been obtained from the presence of a fossil florula composed of more than fifty genera which would indicate definitely that the climate in the vicinity of Forester during late Algonquin time was at all different from that prevailing there today. The species in the fossil forest are, for the most part, those characteristic of the beech maple forest growing in that particular region today (Quick, 1923, p. 228). Certain species of secondary importance which are characteristic and abundant in the climax forest in the northern part of the Lower Peninsula, as, for example, *Taxus canadensis*, *Acer pennsylvanicum*, *Acer spicatum*, *Gaylussacia baccata*, *Lonicera canadensis*, and *Sambucus racemosa*, were absent in the fossil material, with the exception of *Sambucus racemosa*. This species, although prominent in the north, is found sparingly in the southern part of the state. The much greater abundance of fossil seeds of *S. canadensis* appears to indicate that it was more prominent than *S. racemosa* in the Forester region during later Algonquin time, as it is now in the modern flora.

The large amount of hemlock, also more prominent in the climax forest farther north, might be interpreted as indicating a lower temperature. But, on the other hand, hemlock is to be found reproducing itself today in a beech maple grove within a mile of the Forester deposit. Since the deposit undoubtedly contains remains from an area of rather limited dimensions, the reasons are equally strong for not interpreting the abundant remains of this species as an indication of a lower temperature than that which occurs there today.

The abundance of Platanus and the presence of Nyssa indicate a relatively warm climate similar to that of the present. The northern limit of the range of these two species in the Lower Peninsula today is only fifty to seventy-five miles north of Forester. The occurrence of these two species during Algonquin time so near to the northern limits of their present ranges strongly indicates climatic conditions similar to those now prevailing in that vicinity.

The close proximity of the ice front, 240 to 250 miles distant, apparently had little if any effect on the climate, at least so far as the type of vegetation was concerned. All the species in the fossil florula which have a characteristically wide northern distribution may be found growing some distance south of Forester today. Upham (1895) recognized that the nearness of the margin of a continental ice sheet to a certain region would not materially affect the temperature, and he believed it to be entirely possible for a warm temperate flora and fauna to keep pace with the glacial recession.

Of the 416 species of vascular plants found growing on the narrow rim of land surrounding the continental ice cap in Greenland, Fernald (1925, pp. 245–246) says: ". . . 275 (67% of the Greenland flora) occur south of the St. Lawrence or the Straits of Belle Isle, 243 of them (58½% of the Greenland flora) being known at or near sea-level; and 100 species (24% of the Greenland flora) occur in Massachusetts, Rhode Island or Connecticut. Furthermore, 75 species which occur in Greenland (18% of its flora) are plants of temperate eastern America which reach their northeastern limits in America (outside of Greenland) at or near the Straits of Belle Isle."

At Mendenhall Glacier, near Juneau, Alaska, Taylor (1932, p. 387) noted that the first pioneers appeared on glacial sand 2,170 feet away from the face of the glacier, and that *Picea sitchensis* and *Tsuga heterophylla* were present with them. At a distance of 6,070 feet from the margin of the ice he found a subclimax forest composed exclusively of spruce seventy-five years old.

Cooper (1942) pointed out that the fossil coniferous forest near Minneapolis, Minnesota, described by Cooper and Foot (1932), was well established when the continental ice front was only 150 miles or less distant. And close proximity to a receding ice sheet is not prohibitive to shrub and tree growth in similar situations in Alaska, where in some places alder thicket and spruce forests grow on abla-

tion moraines that rest upon stagnant ice (1923). But he suggested caution in drawing parallels between the conditions in Alaska today with those surrounding a continental ice sheet on the interior of a continent.

In Michigan there may have been local conditions which hastened the development of a beech–maple climax forest. In the Lower Peninsula the range of many southern plants extends farther north along both the Lake Michigan and the Lake Huron shores than in the center of the state, and likewise the range of many northern plants extends farther south along the two shorelines than throughout the interior of the state. It is known that the Great Lakes tend to equalize the temperature of the land surfaces near by (Schneider, 1917, p. 1). In an ecological study of Michigan vegetation Quick (1923, p. 234) made the following statement: "The more moderate climate of the lake shores allows the northern plants to remain here uninjured by the heat of the summer, and at the same time allows a northward advance of southern species in the same regions because of the lessened severity of the winter." It is altogether possible that the same conditions prevailed during Algonquin time and that a beech–maple climax forest invaded Michigan along the eastern side of the state more rapidly than in the central part. The strip of lake clay along the eastern side of the "Thumb" (Leverett and Taylor, 1915, pl. 7) doubtless caused a more rapid development of the vegetation to the climax forest condition. The high water-holding capacity of the clay would make it possible for humus to develop rapidly and thus prepare the soil for occupancy by a mesophytic forest. The region to the north and south of Forester bordering on the lake was no doubt also characterized by the same type of forest, since the soil is generally the same.

The fossil forest indicates that optimum growing conditions had been attained during late Algonquin time in the valley of Big Creek, near Forester, Michigan, with respect to (1) moisture, (2) soil, and (3) atmospheric factors. On the basis of the evidence at hand the climate in Sanilac County at that time may be regarded as having been similar to that prevailing there today. Whether or not this forest of late Algonquin time remained unaltered by climatic fluctuations during the intervening time up to the present has not been proved. However, no significant change in type of forest vegetation

was indicated by the fossil remains in the strata of the old estuary which existed during the time of the last or highest stage of Lake Algonquin, a period of approximately four thousand years. It is significant that there is in the Forester area at the present time a climax forest similar in its component species to the fossil forest which flourished there over ten thousand years ago.

SUMMARY

1. A postglacial deposit in Sanilac County, near Forester, Michigan, is described.

2. The deposit was formed during the last or highest stage of glacial Lake Algonquin.

3. The deposit is of considerable antiquity and is about 10,500 years old.

4. The fossil material identified represents thirty-three families, fifty-three genera, and forty-nine species.

5. The fossil florula represents a beech–maple climax forest made up of the same plants which characterize the climax forest in the southern half of the Lower Peninsula of Michigan, rather than the climax forest of the northern part of the Lower Peninsula and in the Upper Peninsula.

6. The presence of a beech–maple climax forest during late Algonquin time indicates that optimum growing conditions had been attained in that locality with regard to (1) soil, (2) rainfall, and (3) temperature.

7. The climate is considered to have been similar to that prevailing today in Sanilac County, Michigan.

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1

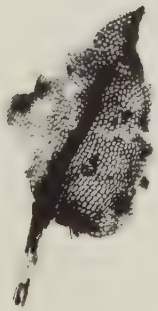
2

FIG. 1. Exposures in the north and south banks of Big Creek, near Forester, Michigan (photograph by Mr. L. A. Harris)

FIG. 2. Section exposed in the north bank of Big Creek

1

2



3

FIG. 1. Fossil leaves weathered out from Stratum 1
FIG. 2. *Thuidium delicatulum* (Hedw.) Mitt. Habit of plant. × 20
FIG. 3. *Thuidium delicatulum* (Hedw.) Mitt. Part of a single leaf. × 70

EXPLANATION OF PLATE III

FIG. 1. *Leucodon sciuroides* (L.) Schwaegr. A single leaf. × 75

FIG. 2. *Anomodon attenuatus* (Hedw.) Hüben. A single leaf. × 75

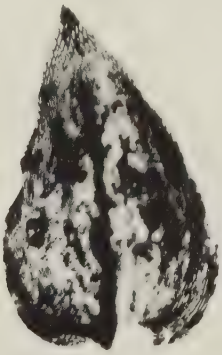
FIG. 3. *Eurhynchium strigosum* (Hedw.) J. and S. Habit of plant. × 30

FIG. 4. *Eurhynchium strigosum* (Hedw.) J. and S. A single leaf. × 75

1

2

3



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EXPLANATION OF PLATE V

FIG. 1. *Sagittaria latifolia* Willd. Achenes. × 4

FIG. 2. *Dulichium arundinaceum* (L.) Britton. Achene. × 4

FIG. 3. *Carex lupulina* Muhl. Achene. × 4

FIG. 4. *Carex retrorsa* Schwein. Achenes. × 4

FIG. 5. *Carex Schweinitzii* Dew.? Achenes, one enclosed within perigynium. × 8

FIG. 6. *Ranunculus septentrionalis* Poir. Achene. × 4

FIG. 7. *Anemone sp.* Achene. × 4

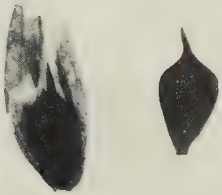
FIGS. 8, 9. *Cornus stolonifera* Michx. Seeds. × 4

1

2

3

4



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EXPLANATION OF PLATE VI

FIGS. 1–2. *Tilia americana* L. Bracts. × 1

FIG. 3. *Tilia americana* L. Fruit. × 1

FIGS. 4–5. *Tilia americana* L. Fragments of leaves. × 1

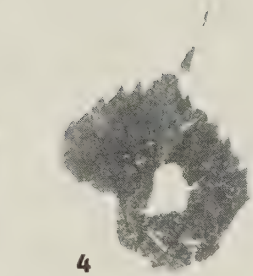
FIG. 6. *Carpinus caroliniana* Walt. Leaf. × 1

FIG. 7. *Carpinus caroliniana* Walt. Seed. × 1

FIGS. 8–9. *Carpinus caroliniana* Walt. Bracts. × 1

1

2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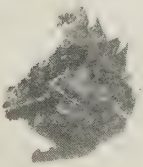
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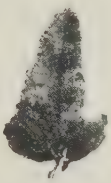
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EXPLANATION OF PLATE VII

FIGS. 1–2. *Fagus grandifolia* Ehrhardt. Fruits. × 1

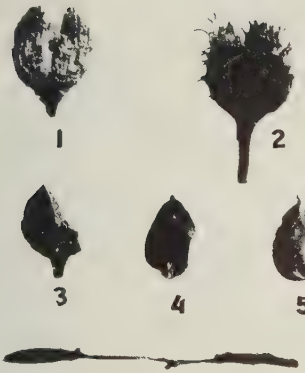
FIGS. 3–5. *Fagus grandifolia* Ehrhardt. Seeds. × 1

FIG. 6. *Fagus grandifolia* Ehrhardt. Twig. × 1

FIG. 7. *Fagus grandifolia* Ehrhardt. Bud scales. × 1

FIG. 8. *Fagus grandifolia* Ehrhardt. Transverse section of wood. × 125

FIG. 9. *Nyssa sylvatica* Marsh. Leaf. × 1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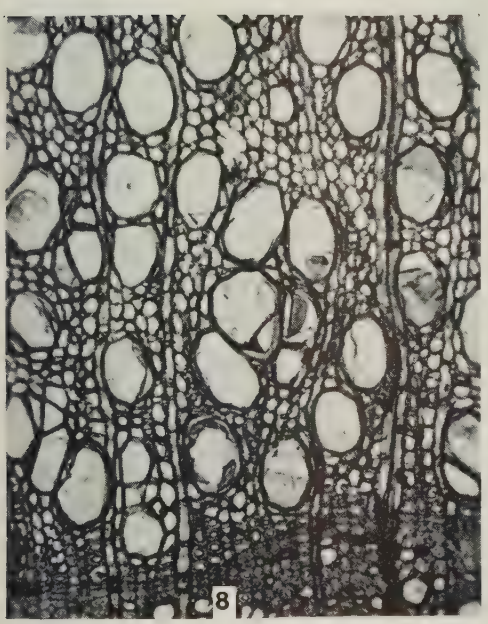
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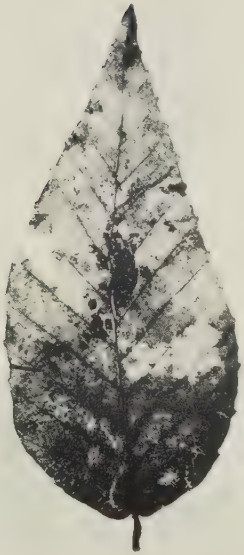
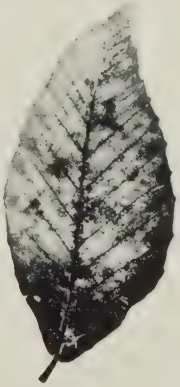
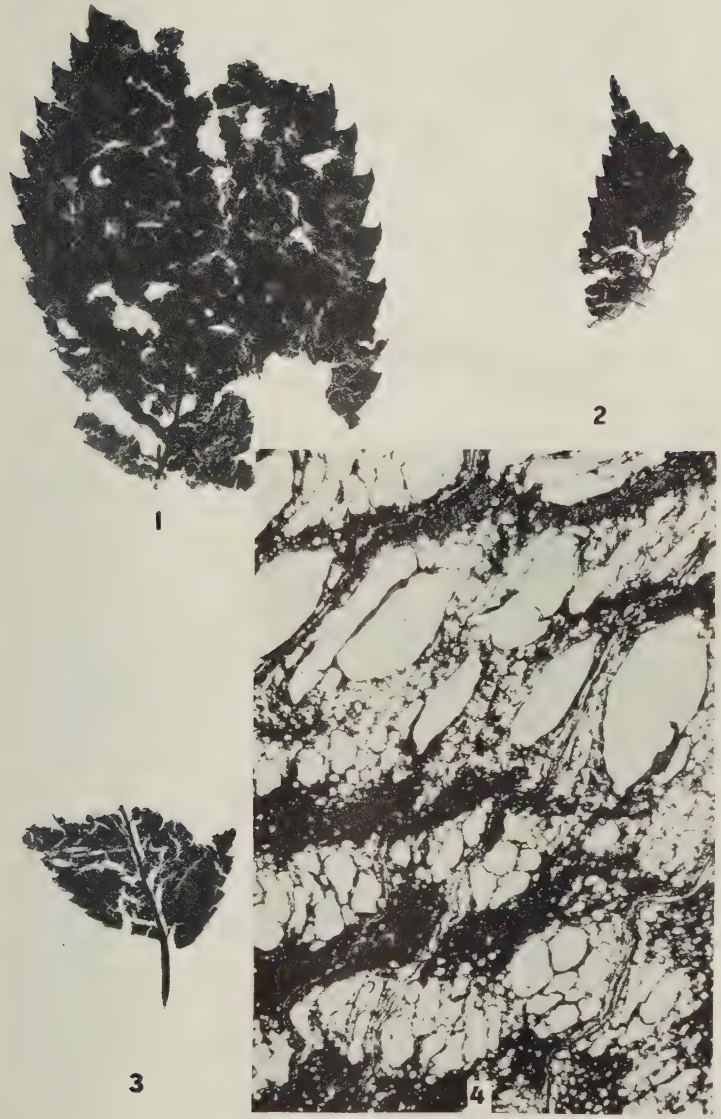




FIGS. 1–4. *Fagus grandifolia* Ehrhardt. Leaves. × 1



Ulmus americana L.

FIGS. 1–3. Leaves. × 1

FIG. 4. Transverse section of wood. × 125

EXPLANATION OF PLATE X

FIG. 1. *Sambucus canadensis* L. Seeds. × 4

FIG. 2. *Sambucus racemosa* L. Seeds. × 4

FIG. 3. *Rubus idaeus* L.? Seeds. × 4

FIG. 4. *Rubus allegheniensis* Porter.? Seeds. × 4

FIG. 5. *Vitis vulpina* L. Seed. × 4

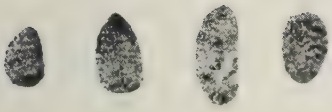
FIG. 6. *Bidens frondosa* L. Achene. × 4

FIG. 7. *Zanthoxylum americanum* Mill. Thorn. × 4

FIGS. 8–9. *Agrimonia sp.* Fruits. × 4

FIG. 10. *Zanthoxylum americanum* Mill. Seed. × 4

FIGS. 11–13. *Laportea canadensis* (L.) Gaud. Achenes. × 6



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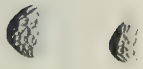

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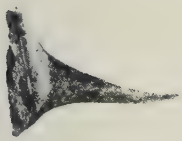

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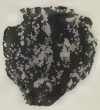

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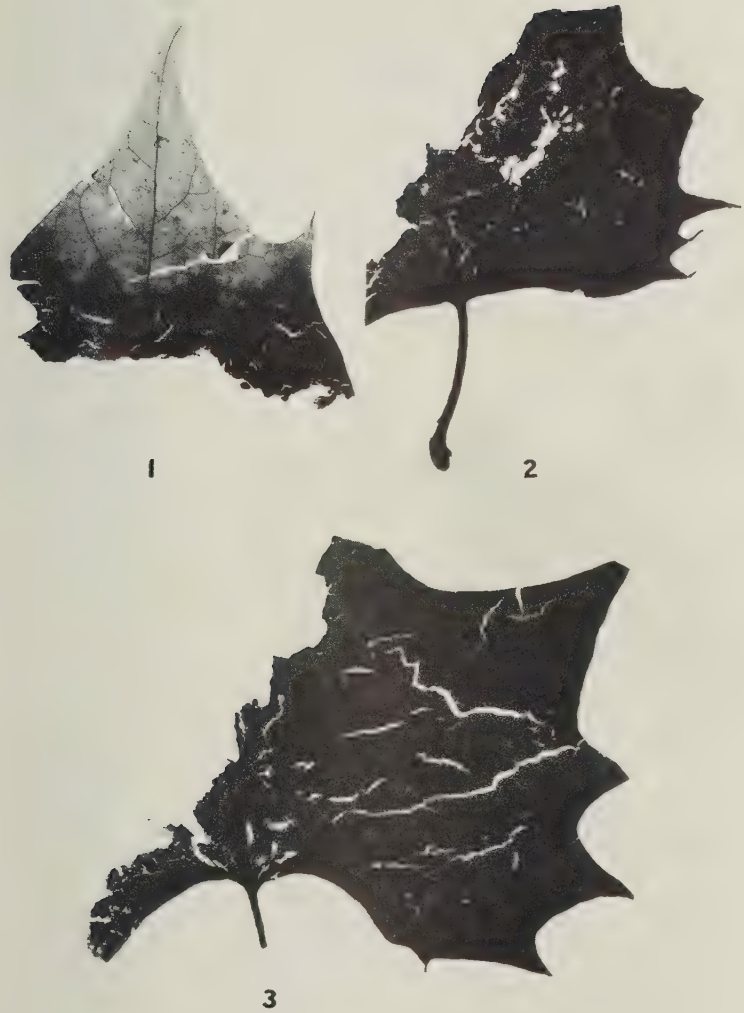
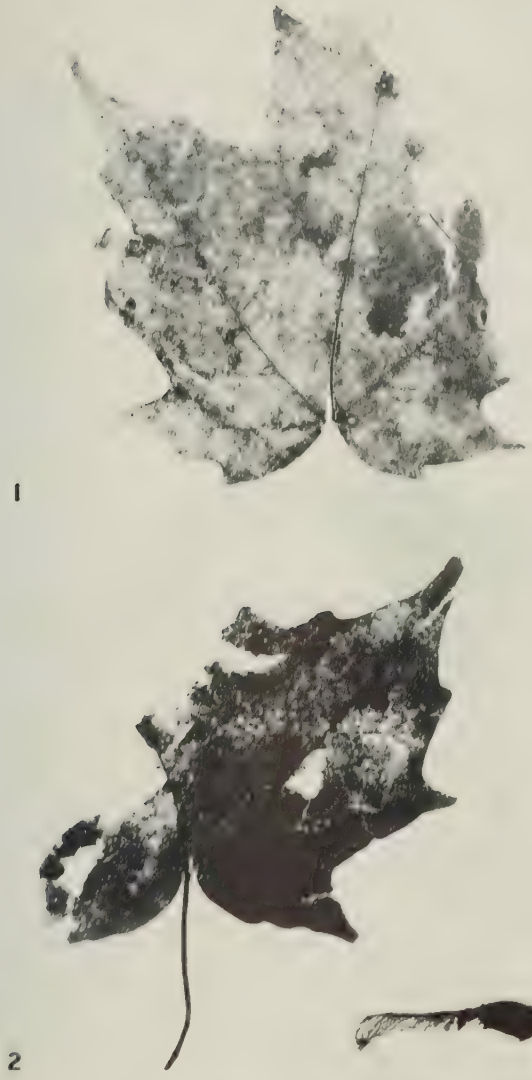


FIGS. 1–3. *Platanus occidentalis* L. Leaves. × 1

2

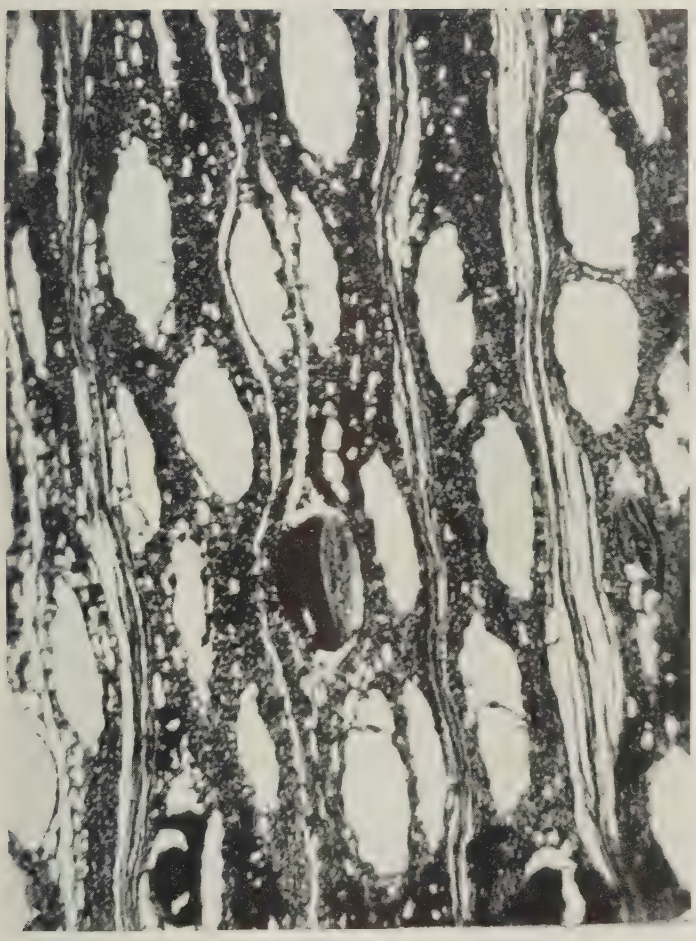
3

Fig. 1. *Platanus occidentalis* L. Transverse section of wood. × 125
Fig. 2. *Crataegus sp.* Leaf. × 1
Fig. 3. *Platanus occidentalis* L. Part of a leaf. × 1

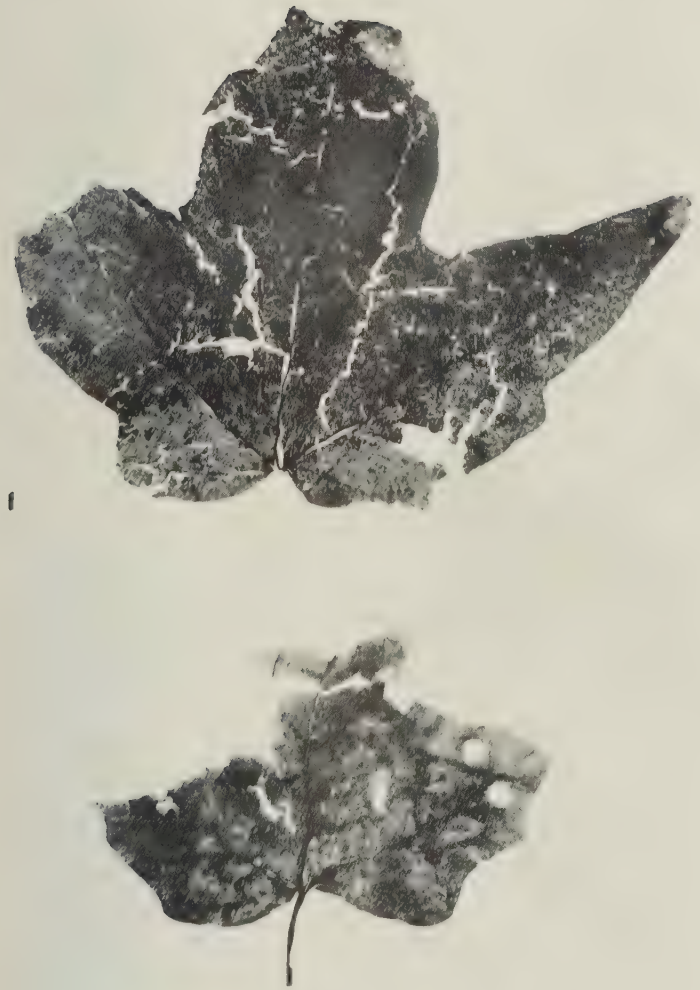


Acer saccharum Marsh. × 1

FIGS. 1–2. Leaves. FIG. 3. Seed

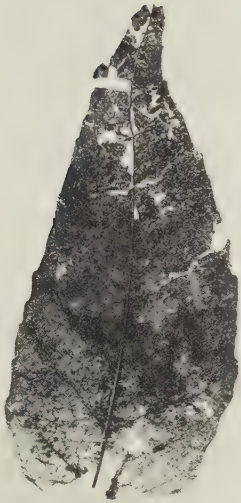


Acer saccharum Marsh. Transverse section of wood. × 125



Figs. 1–2. Leaves of *Acer saccharum* var. *Rugelii* Rehd. (?) × 1

1



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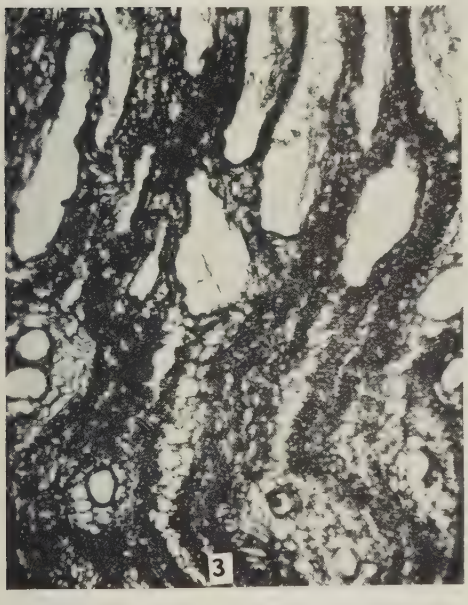

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FIGS. 1, 2, 4. *Fraxinus sp.* Leaflets. × 1

FIG. 3. *Fraxinus nigra* Marsh. Transverse section of wood. × 125

FORESTRY

SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES. XVIII *

DOW V. BAXTER

FIELD observations over much of North America and Europe indicate that practically all the resupinate polypores from the region of the Great Lakes grow elsewhere on our continent and that a large number of them occur in Europe. Among the many species common to both Europe and North America it appears that the North American specimens exhibit even wider variations in growth and structural features than do specimens found abroad. Perhaps this is because of a greater number of kinds of substrata and the more divergent environments on our continent than in Europe. It is only natural that these facts should lead to the description of a large number of species here, but it is likely that at least several of the plants are actually forms or races and do not deserve specific rank. It is for this reason that a study of the characteristics of American plants in culture is becoming increasingly important.

Polyporus abietinus may be cited as an example of a plant that is found on both continents and that exhibits a wide range of variation. I was unable to find our common and closely allied *Pol. pargamenus* on the aspen about Uppsala although environmental

* Throughout the work on these monographs I am indebted to many institutions and individuals for suggestions, help, and privileges extended to me. Grants from the Horace H. Rackham School of Graduate Studies, of the University of Michigan, have greatly facilitated both the field and the laboratory studies. My appreciation is expressed particularly to the men who have accompanied me on my numerous expeditions to Alaska, the Yukon Territory, and the Northwest Territories. Much credit is due them for aiding in the collection and care of specimens and for living, at times, under rather difficult circumstances. I am under obligation to Professor T. G. Halle of Naturhistoriska Riskmuséet in Stockholm, with whom I have had the pleasure of association. Thanks are due several American institutions and scholars, also. To the authorities at the New York Botanical Garden, to the staff of the Division of Pathological and Mycological Collections of the United States Department of Agriculture, and to Professor H. H. Bartlett, of the University of Michigan, I am especially indebted.

conditions for *Pol. abietinus* and *Pol. pargamenus* in this country seem to be identical and *Pol. abietinus* was plentiful on the spruce in Sweden. At least two distinct forms of *Pol. abietinus*, however, do occur in Europe and these have received specific names under two different genera (18). The extreme morphological variants of this plant are represented chiefly by the porose form of *Pol. abietinus* (Dicks.) Fr., in the limited sense, and by forms in which teeth, or even lamellae, appear. This latter plant has been designated in Europe as *Irpex fuscoviolaceus* (Ehrenb.) Fr. In America the fungus presents many variations, and it may at first seem hopeless to try to draw distinct limits between the different forms. Interfertility between porose and other forms from America and Europe has been demonstrated, so that at least several of them must be regarded as conspecific. Robak (18) has cited an additional example; he has demonstrated that the submerged hyphae of *Trametes odorata* of Europe and *T. americana* Overh. of North America "intermingled readily," and so he regards *T. americana* as only a subspecies of *T. odorata*.

This, the eighteenth paper in the present series, represents a continuation of the study of the resupinate polypores with reference to their occurrence in the field, their distribution, and their morphological characteristics, as well as their features in culture. Two new species (*Poria herbicola* and *P. Diospyri*) and two new varieties are described.

Poria herbicola sp. nov.

(Plate I)

Type:

Poria herbicola sp. nov. on soil, Ann Arbor, Michigan. Coll. Dow V. Baxter, July 15, 1945. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio annua, effusa per caespites graminum et trifoliorum, 30 cm. diam., prope culmos et laminas graminum nodulosa sterilisque, alba vel albida, nondum mortua subsicca et subcoriacea, siccitate dura et ossea; marginibus fertilibus; poris 1–2 mm. (plerumque 2 mm.) longis, siccitate solum 0.5–1 mm. (vel minus); orificiis angularibus, 0.5–1 mm. diam., albis vel pallide salmonicoloribus, aetate cinerescentibus; sporis 4(5) μ longis, 3 μ crassis; hypharum membrana tenui; hyphis vivis 4(5) μ crassis.

Specimen typicum legit Dow V. Baxter, no. 23165, prope Ann Arbor, Michigan, Jul. 15, 1945; in herb. auctoris conservatum.

Fructification annual, effused over lawn in patches approximately 30 cm. in diameter and killing the grass, becoming nodular and sterile about grass blades, white or whitish in both fresh and dried specimens, dry and somewhat coriaceous even when fresh, drying hard and bonelike; margins becoming fertile; tubes 1–2 mm. (mostly 2 mm.) long when fresh, drying down to 0.5–1 mm. or less; mouths angular, 1 or 2 to a mm., white to "pinkish buff" when fresh, graying, when dried, to "light buff"; spores 4(5) × 3 μ; hyphae thin-walled, 4–5 μ in diameter, when fresh mostly 4 μ.

Allied species. — The habitat of this plant suggests that it might be *Poria terrestris*, or at least be related to one or more of the interpretations given that species — especially since almost any specimen found on soil has acquired that name. *P. terrestris* Pers., however, becomes brownish red upon drying, as does *P. terrestris* DC. (*Fl. fr.*, 6 : 39 = *P. mollicula* Nob. p. t. [Lloyd, *Myc. Not.*, n. 40, p. 543], non *P. terrestris* Pers. nec Bres. ex Bourdot and Galzin). The majority of the specimens under this name examined in European herbaria are brown or reddish brown and do not suggest *P. herbicola* in color upon drying. The spores of *P. terrestris* Pers. are somewhat larger, i.e. 5–6 × 3.5–4 μ (Bourdot and Galzin). Color variations between the dried plants of other interpretations mentioned will serve as the best means of distinguishing them.

Dried specimens of *Poria herbicola* suggest *P. rancida* Bres., which also grows on fallen needles and sticks, but that species does not remain so whitish, becoming more "pinkish buff" upon drying. Furthermore, the spores of that species are 5–7 × 2.5–2.7 μ (Bourdot and Galzin).

Habitat. — On soil and grass.

Distribution. — Michigan.

Poria Diospyri sp. nov.

(Plate II)

Type:

Poria Diospyri on *Diospyros virginiana*, Sand Springs, Oklahoma. Coll. Lt. Albert T. Lagemann and Dow V. Baxter, Aug. 25, 1945. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio annua vel perennis, usque ad 1 m. in ligno *Diospyri virginianae* effusa; plantis annuis plerumque 2 mm. crassis, albidis vel pallide ochraceis, plantis perennibus ca. 5 mm. crassis, plerumque albidis vel subsulphureis; poris 0.5–3 mm. longis, in speciminibus vetustis plerumque 2.5 mm. longis, 2- vel 3-stratis; orificiis $\frac{1}{6}$ vel $\frac{1}{5}$ mm. diam., albis vel siccitate pallide luteiochraceis; sporis 3–4 μ longis, 2–3 μ crassis, plerumque 3×4 μ; hyphis hyalinis saepe incrustatis, septatis vel haud septatis, diam. 3–5.5 μ.

Specimen typicum legerunt Lt. Albert T. Lagemann et Dow V. Baxter, no. 23166, prope Sand Springs, Oklahoma, Aug. 25, 1945; in herb. auctoris conservatum.

Fructification annual or perennial, effused for as much as 1 meter; one-year-old plants mostly about 2 mm. thick, whitish to tan, older specimens approximately 5 mm. thick, mostly white or slightly sulphureous; tubes 0.5–3 mm. long, in old specimens usually 2.5 mm. long, in two or three layers; mouths mostly 5–6 to a mm., white, drying "ivory-yellow" to "cream-buff" to "chamois"; spores (2)3 × (3)4 μ; hyphae hyaline, often incrusted, septate or nonseptate, 3–5.5 μ in diameter.

Allied species. — Annual specimens of *Poria Diospyri* suggest some of the many growth forms of *P. versipora* because of their color and texture, especially since it is common for *P. versipora* to live through the winter. *P. Diospyri* suggests *P. versipora* only in annual growth forms, however, for, with age, it becomes a thick plant, the mouths, if not whitish, are more brown than "cinnamon-buff" and are much smaller (5–6 to a mm.) than those of *P. versipora* (1–3 to a mm.), and the dissepiments are not dentate. Older specimens of *P. Diospyri* are also somewhat chalky in appearance, a feature that is not characteristic of *P. versipora.*

Differences between thin and older forms are great enough to make them appear at first glance to be two species. The plants studied, however, were collected on the same log, and the development of the old from the younger forms was traced in the field. Thicker and older specimens resemble *Poria xantha crassa* much more than they do *P. versipora.* The mouths of the tubes in both porias are of small diameter. Furthermore, the color in mature specimens of *P. Diospyri* may be sulphureous ("ivory-yellow")

as in *P. xantha crassa*. Chalky appearance and checking upon drying are characteristic of both plants. These porias may be separated by their spores, which are allantoid, 4–6 × 1–1.5 μ, in *P. xantha crassa* and 3 × 4 μ in *P. Diospyri*.

Habitat. — *Diospyrus virginiana.*

Distribution. — Oklahoma.

Fomes robustus Taxodii var. nov.

(Plate III)

Type:

Fomesrobustus Taxodii var. nov. on *Taxodium distichum*, Okeefinokee swamp, Georgia. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio partim perennis, in areis 1–4 persistens et incrementis stratosis annuis gradatim minoribus accrescens, plerumque adnata sed saepe ad marginem separans; marginibus primum 1–2 mm. latis, rosaceibrunneis, aetate fertilibus, crassioribus, subluteibrunneis; subiculo tenui, plerumque minus quam 1 mm. crasso; strato composito, tubuloso usque ad 3 cm. crasso, sed saepe minus quam 1 cm. et eo Poriae typicae lignosae simili modo "generis" Fomitiporiae; tubis annuis, 2–4 mm. longis, obvie stratosis, ore subcircularibus, crassis, integris, 5–7 in uno mm., ochraceis vel brunneis; sporis globosis 5–8 μ diam.; hyphis subiculi brunneis, simplicibus, non septatis, 2–5–3.5 μ diam., setae desunt.

Specimen typicum legit D. V. Baxter in ligno *Taxodii distichi*, in locis lacustribus "Okeefinokee Swamp," Georgia; conservatum in herbario auctoris.

Fructification perennial in small patches, mostly adnate, but often separating at the margins upon drying; margin at first 1–2 mm. wide, "Saccardo's umber," becoming fertile and, often, thick and "Verona brown"; subiculum thin, mostly less than 1 mm. thick; tube layers reaching a thickness of about 3 cm., but often less than 1 cm. thick, and resembling those of a typical non-woody poria as much as do the tube layers of perennial forms that have been classed as Fomitiporia; tubes 2–4 mm. long each season, rather distinctly stratified; mouths subcircular, thick-walled, entire, averaging 5–7 to a mm., "clay-color," "buckthorn-brown," or "raw sienna"; spores globose, 5–8 μ in diameter;

hyphae of subiculum brown, simple, nonseptate, 2.5–3.5 μ in diameter; no setae.

Allied species. — The new variety, which grows on bald cypress, differs chiefly in size from *Fomes robustus tsuginus* (Peck) Overh., which is very common on *Tsuga canadensis* and *T. heterophylla* and much less abundant on western species of Abies. *F. robustus Taxodii* does not cover large areas of log surface and the tubes are commonly in one layer, that is, the plant is often less than 0.5 cm. thick and never becomes so multilayered as does the species. In this form it more nearly resembles *Fuscoporia juniperina* Murr. than it does the allied variety *tsugina.* It is to be distinguished from *Fuscoporia juniperina* by its orbicular type of growth and by its greater thickness at maturity. The receding type of growth exhibited in old specimens of the variety *Taxodii* is not evident in *Fuscoporia juniperina.* The spores of *Fuscoporia juniperina* are 5–6 μ and are therefore smaller, and setae occur in that species, but not in *Fomes robustus tsugina.* Fruiting bodies of the variety *Taxodii* do not appear at the junction of a branch, as those of the species usually do, and the variety does not occur on standing trees.

Habitat. — *Taxodium distichum.*

Distribution. — Georgia.

Decay. — *Fomes robustus Taxodii* produces a white rot in cypress. The decayed wood separates into sheets.

Polyporus abietinus (Dicks.) Fr., Syst. Myc., 1: 370. 1821

(Plate IV)

Boletus abietinus Dicks., Pl. Crypt. Brit., 3 : 21. 1793.
Boletus incarnatus Schum., Enum. Pl. Saell., 2 : 391. 1803.
Polyporus parvulus Schw., Trans. Am. Phil. Soc., II, 4 : 157. 1832.
Polystictus abietinus (Dicks.) Cooke, Grevillea, 14 : 84. 1886.
Coriolus abietinus (Dicks.) Quél. Ench. Fung., p. 175. 1886.
Poria caesioalba Karst. in Sacc., Syll. Fung., 6 : 305. 1888.
Polystictus pusio Sacc. & Cub. in Sacc., Syll. Fung., 6 : 265. 1888.
Daedalea unicolor violacea Clements, Crypt. Form. Colo., no. 170. 1905.
Lenzites Abietis Lloyd, Mycol. Notes, 6 : 909, f. 1607. 1920.
Hirschioporus abietinus (Dicks.) Donk, Mededeelingen uit het Botanisch Museum en Herbarium der Rijksuniversiteit te Utrecht, 9 : 168. 1933.

Important specimen:
Physisporus caesioalbus Karst. on Abies. Herb. of Bresadola, Stockholm.

Forms

f. *fuscoviolaceus* (*Irpex fuscoviolaceus* [Ehrenb. ex Fr.] Fr.). This form is generally regarded as irpicioid, but is sometimes described as including even lamellate types. It is here restricted to irpicioid plants. The form is otherwise similar to the species and has been shown in cultures (18) to be conspecific with porose forms.

f. *Abietis* (Lloyd) Overh. This form has a lamellate hymenium and does not include irpicioid plants. American lamellate plants have been shown to be conspecific with porose collections by Robak (18).

f. *Thelephoroides* forma nov. (Pl. VI. This form is described on p. 203.)

Fructification thin, coriaceous, sessile, effused-reflexed or resupinate, but usually reflexed at margins at least; surface zonate, tomentose-strigose, white or gray, "vinaceous buff," or "avellaneous"; margin thin, undulating; context pallid, less than 1 mm. in width; tubes less than 1 mm. long; mouths at first "livid purple," becoming "vinaceous fawn" to "vinaceous buff" or "avellaneous," 2–3 to a mm., subround or angular, becoming sinuous, irpicioid, or even lamellate; basidia 4–7 μ broad; spores smooth, hyaline, subcylindric to allantoid, 6–9 $\times$ 2–3 μ; hyphae 2–4 μ in diameter; cystidia numerous or rare, 4–9 μ in diameter, sometimes projecting up to 20 μ or more, hyaline, smooth or incrusted at the apex.

Allied species. — *Polyporus abietinus* is represented by porose and lamellate forms. Some of these have been described as species (see Pl. V). Those that have teeth or lamellae, for example, are often known under the name *Irpex fuscoviolaceus* (Ehrenb. ex Fr.) Fr. In America the lamellate form has been designated as *Pol. abietinus Abietis* (Lloyd) Overh., also. Irpicioid or lamellate forms (*Irpex fuscoviolaceus*) are regarded by Robak (18) as "subspecies." His work with both American and Norwegian porose, irpicioid, and lamellate forms in culture indicates that they are, at any rate, conspecific.

Polyporus pargamenus Fr. is one of the most common of the American species allied to *Pol. abietinus*. Microscopic features are, for the most part, similar in the two plants, and the spores fail to furnish any means of distinguishing the two polypores.

It is pointed out by Rhoads (16) that in the usual hydnoid form *Pol. pargamenus* cystidia are of infrequent occurrence, whereas *Pol. abietinus* is characterized by abundant, prominent capitate cystidia. But porose forms of *Pol. pargamenus* have the same type of cystidia as *Pol. abietinus*, so that this character cannot be used to separate the two species. It is generally possible, however, to distinguish between the two plants by the difference in size. The fruiting body of *Pol. abietinus* seldom exceeds 3 cm. in length, whereas *Pol. pargamenus* is larger, reaching 7 cm. *Pol. pargamenus*, furthermore, is usually fan-shaped and is attached to the substratum by a narrow stalklike attenuation. The fruiting bodies of *Pol. abietinus* may occasionally be fan-shaped, by the place of attachment is broader (19) and never stalklike. Distinctions may usually, but not always, be based on the fact that *Pol. abietinus* is generally found on coniferous wood, whereas *Pol. pargamenus* ordinarily grows on wood of dicotyledonous tree species. In the region of the Great Lakes aspen is the most common substratum of *Pol. pargamenus*. In the spruce and pine forests of Sweden where aspen is present *Pol. abietinus* occurs abundantly, but I have never found either it or *Pol. pargamenus* on aspen there.

The hymenium of *Polyporus subchartaceus* may be purplish, and since the spores and cystidia are the same as in *Pol. abietinus* and the fungus is usually found on aspen and cottonwood, *Pol. subchartaceus* should be mentioned in a discussion of either *Pol. abietinus* or *Pol. pargamenus*. The thickness of the pileus, which is greater than 4 mm., may be used to separate *Pol. subchartaceus* from *Pol. abietinus*. The pileus is less than 4 mm. thick in *Pol. abietinus*, as well as in *Pol. pargamenus*.

Names such as *Lenzites abietina* and *L. striata* appearing in the literature may lead to some confusion, especially since the genus Lenzites includes lamellate plants. These are, however, related to the brown *Lenzites saepiaria*.

Habitat. — *Abies amabilis, A. arizonica, A. balsamea, A. concolor, A. grandis, A. lasiocarpa, A. magnifica, Chamaecyparis thyoides, Cupressus macrocarpa, Larix laricina, L. Lyallii, L. occidentalis, Libocedrus decurrens, Picea Engelmannii, P. glauca, P. mariana, P. sitchensis, P. rubra, Pinus attenuata, P. Banksiana, P. contorta, P. Coulteri, P. echinata, P. edulis, P. flexilis, P. glabra,*

P. lariceo-austriaca, P. monticola, P. palustris, P. ponderosa, P. radiata, P. resinosa, P. rigida, P. Sabiniana, P. silvestris, P. Strobus, P. virginiana, Populus trichocarpa, Prunus emarginata,[1] *Pseudotsuga macrocarpa, P. taxifolia, Sequoia sempervirens, Sorbus americana, Thuja occidentalis, T. plicata, Tsuga canadensis, T. heterophylla, T. Mertensiana.*

Distribution. — Alberta, British Columbia, Labrador, Manitoba, New Brunswick, Newfoundland, Northwest Territories, Nova Scotia, Ontario, Prince Edward Island, Quebec, Saskatchewan, Yukon Territory; Alaska, Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Hampshire, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

Occurrence. — *Polyporus abietinus* is one of the most widely distributed polypores on conifers throughout the continent. Many new geographic records of the occurrence of this fungus are reported here, especially for the territories and provinces of Canada. Authentic accounts of its presence in Illinois, North Dakota, and Oklahoma are lacking. A few records of this conifer-inhabiting fungus on dicotyledonous woods exist. A collection is reported (22), for example, on *Populus trichocarpa.* The fungus is one of the first of the polypores to attack fire-killed, dead, or fallen conifers and is especially common on pulpwood and lumber, causing decay during storage.

Fruiting bodies may appear as early as two months after a tree has been felled. In regard to white-pine slash in New England, Spaulding (21) reports that rot of sapwood by this fungus becomes apparent in the larger pieces of slash, which have thick layers of sapwood, during the second year. Sap rot caused by this species is well advanced in New England white-pine slash by the fifth year. *Polyporus abietinus* is next in frequency of occurrence to *Lenzites saepiaria* (21), which probably rots more New England white-pine slash than any other fungus.

[1] Record furnished by Dr. Ruth Macrae, of the Central Experiment Farm, Ottawa, Canada, who confirmed the identity by pairing cultures.

Polyporus abietinus attacks only partly shaded slash, and fruits commonly on the lower sides of the rotted limbs. It requires more moisture in the wood than *Lenzites saepiaria.* In other sections of the continent, especially where rainfall is abundant, as in the coastal forests of southeastern Alaska, decay caused by *Pol. abietinus* may be limited by too much moisture in the shade, and in such regions the fungus is often found on exposed slash off the ground or on standing snags and dead trees. Sap rot of *Pinus ponderosa* in Klamath County, Oregon, appeared principally in the second season after cutting, as did decay in slash of *Pinus Strobus* (Boyce, 4).

In fire-killed West Coast Douglas fir, this fungus is said by Kimmey and Furniss (14) to be the most important species producing decay only in the sapwood, for it causes more than fifty per cent of the decay in that type of wood. *Fomes pinicola* is regarded as the most significant fungus producing decay in both sapwood and heartwood. Nevertheless, it is emphasized that *Polyporus abietinus* probably causes the most loss to owners of old-growth fire-killed Douglas fir, for it is the source of the principal decay in trees of this type for the first five to ten years, and much timber of this kind is salvaged during that time.

Boyce (5) likewise reports, in his studies of the deterioration of wind-thrown timber on the Olympic Peninsula, Washington, that *Polyporus abietinus* attacked the greatest number of trees, but he emphasizes that the greatest total loss through decay was caused by *Fomes pinicola* and the next greatest by *F. applanatus.* This is explained by the fact that the wood attacked by *Pol. abietinus* is usually confined to the outer one-half inch of sapwood. Boyce points out that the record of fruiting bodies gives an idea of the relative abundance of a fungus, but the true measure of its importance is the amount of decay it causes. (It should be added that the importance of a fungus is proportionate to the amount of decay in reference to the specific type of product to be manufactured from the timber.) Deterioration in Douglas fir is reported as only 1.3 per cent (board measure) of the total decay; in Sitka spruce, 4.8 per cent; in silver fir, 3.0 per cent; and in western hemlock, 1.4 per cent.

Cultures. — Isolated on *Picea glauca,* from Healy, Alaska. The "light-buff" mycelium forms a thin mat that scarcely envelops

either white-pine or red-gum blocks in one-year-old cultures. The pink so evident in the hymenium of growing specimens in nature was not apparent in this isolate. No pores formed on any of the wood-block cultures. In Norwegian cultures Robak (18) reports that he, too, has failed to observe hymenial formation of *Polyporus abietinus*. Cartwright and Findlay (8) mention one culture that formed pores on malt agar, and Raestad (15) observed porose or irpicioid hymenia on the same medium, but reported them much more frequently in cultures of the form *fuscoviolaceus*. The hymenia observed by these investigators had the purple color characteristic of that developed by plants in nature.

Cultures of the Alaskan isolate most nearly correspond to those of *Poria aneirina* isolated from *Populus balsamifera*, Moose Pass, Alaska. Both fungi exhibit thin, "light-buff" mycelial mats that scarcely cover either red-gum or white-pine wood blocks in one-year-old cultures. The radiating growth habit of the mycelium in *Polyporus abietinus* as it spreads over the blocks is distinctive.

The optimum temperature for growth of both American and European isolates is about 27° C. Humphrey and Siggers (13) report that a Wisconsin isolate (optimum temperature 28° C.) falls in their intermediate-temperature group, i.e. that with an optimum between 24° and 32° C. The inhibiting point is given as 38° C. Robak (18) places *Polyporus abietinus* in the group of fungi having a moderate to slow growth at room temperature, a grouping that would include the Michigan (Alaskan) isolate. Growth in Norwegian cultures is reported to accelerate with temperature increases to about 25°–26° C. Temperature responses have been used to separate *Pol. abietinus* from the allied *Pol. pargamenus*. Snell and others (20) find that the results in an effort to distinguish these two species by such features were not so striking as those obtained for *Trametes odorata* and *Lenzites saepiaria*, but they were sufficiently varied to provide a temperature differential.

The Alaskan isolate grows equally well in the light and the dark. Its mycelium has no distinctive odor in cultures on malt-extract medium. In fresh cultures the hyphae branch characteristically at very acute angles, thus producing their regular,

radiating arrangement. In older cultures this feature is obliterated, as reported for European cultures (18). Aerial hyphae are 3–5 μ, mostly 3 μ, in width. Conspicuous clamp connections appear commonly on submerged and other hyphae. Swellings resembling chlamydospores are present.

Robak (18) studied the growth rate of *Polyporus abietinus* in various media containing different forms of nitrogen, as well as carbohydrates. He obtained the slowest growth on NH_4NO_2 and $(NH_4)_2SO_4$; the most rapid growth was obtained with urea as the source of nitrogen, the next most rapid with $NaNO_3$, glycocoll, and the next with asparagine. Growth on peptone media was almost uniformly slower than on the last three chemicals mentioned.

Variable results were obtained by Robak on different sugars, but strikingly slow or scanty growth was observed on xylose, galactose, and lactose.

Polyporus abietinus gives a strong positive reaction to tannic-acid medium. It discolors aniline blue added to the agar (18). Like the Alaskan isolate grown on red-gum and white-pine wood, cultures on blocks of Scotch pine and Norway spruce spread slowly over the wood (18). Robak (18) reports the advance of a conspicuous red-brown stain paralleling the progress of the mycelium. This discoloration may be noticed to some extent in white-pine blocks, also. It resembles to a certain degree the secondary stain observed in blocks infected with *Stereum sanguinolentum*, but it is not so reddish and, when the material is dry, it is slightly more yellow-brown. The occurrence is not preceded by any other color. In the stage at which the white areas occur, the brown color has disappeared.

Using five different isolates of *Polyporus abietinus* in Norway-spruce sawdust cultures sterilized at 50° C. for six months, Robak found them to have caused losses of from 2.25 per cent to 5.25 per cent, dry weight. The average loss per strain varied between 2.6 and 4.72 per cent. In block cultures the losses were small, but it was shown that this species was able to bring about late stages of decay, at least locally, within six months.

This fungus produces more kinds of enzymes than have been reported for other wood-destroying fungi with the exception of

Lenzites saepiaria. Fifteen of the more common hydrolytic enzymes are produced (10): emulsin, cellulose, ligninase, amylase, sucrase, maltase, inulase, pectinase, tanninase, pepsin, trypsin, erepsin, urease, asparaginase, and lipase. Four of the more common oxidizing enzymes occur, namely, oxygenase, peroxidase, laccase, and catalase. *Polyporus abietinus* (along with *L. saepiaria*) secretes several enzymes not formed by species of such heartwood-destroying fungi as *Pol. sulphureus* and *Echinodontium tinctorium*, or by the highly specialized cambium attacking *Armillaria mellea.*

Sexuality. — Monosporous mycelia of different forms of *Polyporus abietinus* have been paired. Norwegian porose and irpicioid forms have been found (18) to be intersterile. Furthermore, monosporous mycelia from a porose Canadian sporophore reacted with Norwegian "Irpex" mycelia by forming clamp connections with them. On the basis of such criteria, the forms in question may be considered conspecific (18).

The common American porose form of *Polyporus abietinus* exhibits tetrapolar segregation, whereas the American irpicioid (or lamellate) form has bipolar segregation, according to Robak (18), reporting Macrae's Canadian work. Robak states further, "in spite of this, the last named form has copulated with Norwegian monospore mycelia." The common porose form of *Pol. abietinus* in Norway also exhibits tetrapolar segregation of sexes, according to Robak (18), and Raestad (15) has shown that the form *fuscoviolaceus* is similar in this respect.

Decay. — *Polyporus abietinus* causes one of the most common sap rots of dead coniferous wood. It appears within two or three years after the death of the tree and produces a "pitted" white rot. The first evidence of decay is a faint yellowish or tan discoloration accompanied by a softening of the wood. Later, small white areas or "pockets" appear; these may or may not be filled with whitish fibers. Narrow strips of apparently sound wood remain between the pockets. Often when the cavities are confined to one plane a ring-scale condition appears. The rotted wood in the final stage of decay is spongy. No zone lines are caused by the fungus in the wood.

Polyporus abietinus utilizes either cellulose or isolated lignin as a source of nutrition, but cellulose is a better source than lignin.

Nitrogenous materials are of more importance in the growth of the fungus on lignin than on cellulose (11).

Analyses by Garren [12] of results of decay in loblolly-pine sapwood indicate that both moisture content and specific gravity of the wood are significant in determining the rate of decay by *Polyporus abietinus*. Although the fact that moisture is conducive to decay is generally accepted, there has been some question regarding specific gravity as an index of durability. It seems that the higher the specific gravity of a piece of loblolly-pine sapwood, the more resistant it will be to decay by *Pol. abietinus*.

Reaction to chemicals. — The resistance of *Polyporus abietinus* to sodium fluoride has been tested by Richards [17]. It was found that this species was next to the least resistant of a group of several wood-rotting fungi of which *Poria incrassata* is the least resistant and *Lenzites trabea* the most resistant. The fungi in this group, arranged in order of increasing resistance, are: *Poria incrassata*, *Polyporus abietinus*, *Pol. versicolor*, *Fomes roseus*, *F. pinicola*, *F. subroseus*, *L. saepiaria*, *Polystictus hirsutus*, *F. Pini Abietis*, *F. annosus* (culture now identified as *Irpex tulipifera*), and *L. trabea*.

Polyporus abietinus forma fuscoviolaceus comb. nov.

Irpex (Sistotrema) violaceus Pers., Syn., p. 551. 1801.
Irpex fuscoviolaceus Fr. in El., Hym. Eur., p. 620. 1874.

Important specimen studied:
Irpex fuscoviolaceus Shrad. Fr., Bresadola Herbarium, Rijksmuséet, Stockholm.

Fructification resupinate, but usually with a slightly reflexed fimbriate margin, or, if not resupinate, having fruiting bodies, small, imbricate, slightly pubescent, white or gray; hymenium purple or violet, mostly in the form of gills, about 1–2 to a mm.; basidia 15–24 × 4–6.5 μ; spores hyaline, cylindrical or allantoid, 6.5–8 × 2.5–3.5 μ; cystidia mostly 18–25 × 5–7 μ; hyphae 3–7 μ in diameter (Bourdot and Galzin, in part).

Habitat. — Coniferous wood.

Polyporus abietinus forma **thelephoroides** forma nov.

(Plate VI)

Type:

Polyporus abietinus var. *thelephoroides* on coniferous wood, Lake Quinault, Washington. Collected by C. H. Kauffman in 1925. Herb. Dow V. Baxter, Ann Arbor.

Fructificatio (marginibus inclusis) resupinata, annua, areas circulares confluentes effusasque ca. 15 cm. diam. formans, colore atrogriseas vel atrocaeruleas; margine tenui, simili Thelephorae, pallide brunneigriseo, ca. 1 mm. lato, aetate fertili; subiculo minus quam 1 mm. lato sed distincto, pallide griseicinnamomeo; poris 0.5–2 mm. longis, plerumque 1.5 mm. longis, orificiis angularibus demum laceratis, $\frac{1}{3}$ mm. diam., rosacei- vel caeruleigriseis (in vivo), colore in statu exsiccato vel similibus vel atre griseibrunneis vel obscure nigriviolaceis vel atrogriseis, basidiis 4-sporis; sporis allantoideis, 5–6 μ longis, 2 μ crassis; infibulationibus haud raris. Habitat in ligno coniferarum, prope Lacum Quinault, Washington.

Fructification entirely resupinate, even margins largely appressed, annual, in orbicular patches that become confluent and effused for 15 cm. or more, slate-gray or bluish when fresh; margin thin, resembling that of the genus Thelephora, "drab gray" or "pale brownish drab," mostly about 1 mm. wide, becoming fertile in age; subiculum less than 0.3 mm. wide, but distinct, "light cinnamon-drab"; tubes 0.5–2 mm., mostly 1.5 mm., long; mouths when fresh pinkish or bluish gray, i.e. "pale brownish drab" to "brownish drab" and retaining the colors in herbarium material or becoming "dark grayish brown" to "dull violet-black" or "deep neutral gray," angular, becoming somewhat fringed, 1–3, mostly 2, to a mm.; basidia 4-spored, spores allantoid, 5–6 $\times$ 2 μ; cystidia capitate incrusted or not incrusted, projecting up to 10 μ; hyphae hyaline, occasionally branched and septate, 2–4, mostly 3–4, μ in diameter; clamp connections present.

Allied species. — This plant, unlike a great many collections of resupinate specimens of *Polyporus abietinus*, has a margin appressed to such an extent that it is readily mistaken for a species of the genus Poria. Because of the pinkish-violet color of the margin, Kauffman, according to his field notes, was reminded of

Poria semitincta. The general color of the plant is a dark blue, however, and not whitish as in that species. I can see no resemblance to *P. semitincta*, but can readily understand why Kauffman thought of the genus Poria, especially since the margins are adnate. Microscopic examination shows that this variety resembles representatives of the Thelephoraceae in the habit of growth and the color. The pores, however, are distinct. The variety is corky enough not to be readily confused with *P. purpurea* and species allied to it.

Habitat. — On coniferous wood.

Distribution. — Washington.

Poria bombycina (Fr.) Cooke, Hym. Eur., p. 575. 1874

(Plate VII, Figures 1–2)

Polyporus hians Karst., Fungi Fenniae Exic. 619, ex Bourdot and Galzin, Hyménomycètes de France, 1927.

Important specimen studied:

Polyporus hians Karst. ex Herb. Karsten on pine, Mustiala. Herb. Bresadola, Stockholm.

Fructification annual, appearing in small patches up to about 4 or 5 cm. in width, soft, whitish at first but becoming tawny, mostly mycelioid; margin byssoid; pores forming at first as depressions in the mycelium, thin, developing into tubes up to 1 mm. long; mouths mostly 1–2 to a mm., angular; basidia 24–30 × 7–8 μ (Bourdot and Galzin); spores ellipsoid, 6–7.5 × 4.5–5 μ; hyphae mostly 2–4 μ in diameter, clamp connections present; no cystidia.

Allied species. — This plant looks much like a weathered specimen of *Poria sinuosa*, but it is a softer species. European specimens do not resemble the rhizomorphic *P. Vaillantii*, as is suggested in American literature of plants of this continent.

Habitat. — *Abies grandis, Larix occidentalis, Picea glauca, Pinus contorta, Pseudotsuga taxifolia.*

Distribution. — Newfoundland, Ontario, Yukon Territory; Alaska, Idaho, Montana, New Hampshire, New York, Washington, West Virginia.

Remarks. — The English concept of this species, as reported by Rea in *British Basidiomycetae*, corresponds to the description presented here.

Fomes connatus (Weinm.) Gill., Champ. Fr., 1 : 684. 1878

(Plate VIII)

Boletus populinus Schum., Enum. Pl. Saell., 2 : 384. 1803.
Poria obducens Pers., Myc. Eur., 2 : 104. 1825.
Polyporus connatus Weinm., Fl. Ross., p. 332, 1836, non *Polyporus connatus* Schw., 1832.
Polyporus connatus Fr., Epicr. Myc., p. 472. 1838.
Fomes populinus (Schum.) Cooke, Grevillea, 14 : 20. 1885.
Fomes Meliae (Underw.) Murr., Bull. Torrey Bot. Club, 30 : 232. 1903.
Fomes oxyporus Sauter ex Lloyd in Synopsis of the Genus Fomes (Cincinnati), 283. 1915.

Fructification perennial, sessile, convex, 2–10 × 3–15 × 0.5–4 cm., imbricated or rarely resupinate, surface white or "cinnamon-buff" to "light grayish olive" in herbarium specimens, never rimose with age; usually becoming covered with moss and algae; context white, or whitish, drying to "cinnamon-buff," soft, corky, 0.3–4 cm., mostly less than 2 cm., thick; tubes distinctly stratified, 2–5 mm., mostly about 3 mm., long each season; mouths white to yellowish, glistening when fresh, drying to "clay-color," "pinkish buff," or even "sayal-brown"; spores hyaline, smooth, ellipsoid to globose, 4–5 × 3.5–4 μ; cystidia none or rare, capitate or club-shaped, 3 μ in diameter (Lowe); hyphae seldom branched, 2–4 μ in diameter.

Allied species. — The resupinate forms of this fungus usually occur in the frost cracks and wood cavities of the maple. It is easy to find states intermediate between the resupinate and the typical fructification. The resupinate form has been termed *Poria obducens* Pers. There are no closely allied species. Because the fruiting body is not woody, *Fomes connatus* might suggest, superficially, a species of Polyporus, but it can be readily separated upon examination, since the tubes are distinctly stratified.

Habitat. — *Acer dasycarpum lutescens, A. macrophyllum, A. Negundo, A. rubrum, A. saccharinum, A. saccharum, Aesculus Hippocastanum, A. octandra, Betula lutea, Carpinus caroliniana, Carya glabra, Cornus florida, Fagus grandifolia, Fraxinus americana, Gleditsia triacanthos, Halesia carolina, Hicoria sp., Liquidambar Styraciflua, Nyssa sylvatica, Ostrya virginiana, Quercus alba, Q. Prinus, Sambucus sp., Ulmus americana, U. fulva.*

Distribution. — British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Prince Edward Island, Quebec; Alabama,

Arkansas, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Dakota, Tennessee, Vermont, Virginia, West Virginia, Wisconsin.

Occurrence. — This fungus attacks a number of hardwoods, but it is of economic importance only on sugar maple. Red maple is attacked fully as much as sugar maple. In general, *Fomes connatus* appears to increase in abundance as the host tree approaches the northern limits of its distribution. In Minnesota, for instance, the woodlands in which maple is an important component of the forest are considerably poorer because of *F. connatus* (and, often, other fungi) than are many maple forests of Michigan. This is also true of sections of Ontario, where the maple may be exceedingly defective. The fungus is rare, however, or is not present at all in scattered maple trees at the very limits of distribution and under peculiar local conditions. It appears abundantly in Nova Scotia, but in Newfoundland the relatively few maples, perhaps because of their scarcity, are free from the fungus. As a matter of fact, in spite of persistent search, no specimens of *F. connatus* have been collected in Newfoundland.

Cultures. — Isolated from *Acer saccharum*, Michigan (tissue culture). It has been my experience, and also that of Campbell (6), that isolations from tissues are extremely difficult to obtain because the soft, watery sporophores are contaminated, even when young, by other fungi and bacteria. Campbell reports that the fungus finds conditions on agar media unfavorable and so makes slow growth there. On sterilized hard-maple blocks it grows vigorously, covering the blocks with a dense, thick mat.

The optimum temperature for growth (for an isolate from *Acer Negundo*) is given as about 25° C. The inhibiting temperature for growth is 35° C. (6). This places the fungus in the intermediate-temperature group of Humphrey and Siggers (13), i.e. with optimum growth between 24° C. and 32° C. The fungus is actually on the lower temperature border, however, and it may at times fall into the low-temperature group, i.e. that with optimum growth at 24° or below, since one degree is well within the limits of experimental error.

Porose areas were evident in cultures six weeks old. The fruit-

ing structure produced the capitate incrusted cystidia and globose spores characteristic of *Fomes connatus*.

The fungus exhibits a positive but not a strong reaction to tannic-acid medium, though occasionally the reaction is negative, according to Davidson, Campbell, and Blaisdell (9).

Decay. — *Fomes connatus* first causes the light-colored wood of maple to darken. The more advanced rot has a stringy appearance and is irregular in outline. This is one of the few heart-rotting fungi that decay the wood so completely that a hollow butt results.

The rot rarely spreads more than a few feet in either direction from the fruiting body, so that, as a rule, a cull extending three feet above the highest sporophore is sufficient. Sporophores usually form shortly after a small amount of decay has taken place, so that rotted trees can soon be detected. These should be discriminated against in stand-improvement work (2).

Poria pereffusa (Murr.) Sacc. and Trott., Syll. Fung , 21 : 335. 1912

(Plate IX, Fig. 1)

Fomitiporia pereffusa Murr., North Am. Fl., 9 : 10. 1907.

Type:

Fomitiporia pereffusa Murr. on oak log, Ohio Pyle, Pa. W. A. Murrill, Herb. New York Botanical Garden, New York.

Fructification perennial, for several years broadly effused, up to 15 mm., commonly 8–10 mm., thick, inseparable; sterile margin 0.5–1 mm. wide, slightly inflexed, "drab," becoming blackish in age and finally disappearing, subiculum brown, often superimposed over a narrow black line, less than 0.3 mm. thick, and often scarcely distinguishable in old plants; tubes mostly distinctly, sometimes indistinctly, stratified, inconspicuously whitish-stuffed, "snuff-brown," 2–3 mm. long; mouths glistening, circular to subcircular, 6–8 to a mm. "Saccardo's umber," "raw umber," or "olive-brown," in old specimens becoming "mouse-gray" in the marginal portions of the fructifications; dissepiments entire; basidia 5–6 μ in diameter, spores smooth, faintly brown, ellipsoid to globose, 4–4.5 $\times$ 3–4 μ; setae small, their points only

extending beyond the basidia, 14–24 × 3–6 μ, hyphae of the subiculum 2–4 μ in diameter.

Allied species. — *Poria pereffusa* may be confused with *Fomes igniarius* var. *laevigatus* (*P. laevigata* (Fr.) Cooke). The plants are to be separated largely upon a combination of characters that are, unfortunately, mostly relative. The spores of *P. pereffusa* are small, 3.5–4.5 × 2.5–3.5 μ (Overh.).[2] The spores of *Fomes igniarius laevigatus* are hyaline. It is evident that faint spore colors may readily be mistaken for hyaline, but the spores of the two plants also differ in size. The smallness of the spores of *Poria pereffusa* is distinctive, and if the spores are pale rusty, one can be certain of the identification. Furthermore, the setae are rather numerous in specimens of *F. igniarius laevigata*, whereas in *P. pereffusa* they are not abundant. The tubes of *F. igniarius laevigata* are white-incrusted in the old layers, but inconspicuously whitish-stuffed in *P. pereffusa*. *F. nigricans laevigata* occurs chiefly on species of Betula, whereas *P. pereffusa* is most often found on species of Quercus.

Fomitiporella floridana Murr. suggests *Poria pereffusa*, but does not have any setae (cystidia), according to the description. The spore color (following Overholts' redescription of spore color for *P. pereffusa* and not the original account) is apparently similar.

Habitat. — *Quercus sp.*

Distribution. — Ohio, Pennsylvania; said by Murrill to range from Ontario to Alabama and west to Minnesota.

Fomitiporella melleopora Murr., North Am. Fl., Pt. I, p. 13. 1907

(Plate IX, Fig. 2, and Plate X)

Type and important specimens examined:

Fomitiporella melleopora on *Salix sp.*, Feb. 11, 1886. A. B. Langlois 213. Type. Herb. New York Botanical Garden, New York.

Fomitiporella melleopora on *Populus tremuloides*, June, 1926, Devil's Lake, Wisconsin. Herb. Dow V. Baxter, Ann Arbor.

Fomitiporella melleopora on *Populus balsamifera*, Atlanta, Michigan. Herb. Dow V. Baxter, Ann Arbor.

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[2] Originally the spores were described as hyaline, but Overholts discovered that they were "pale rusty": "The type collection is mostly sterile but on one occasion when I examined it I found the spores as indicated."

Fomitiporella melleopora on *Populus tremuloides*, July 23, 1946, Au Sable River, Huron National Forest, Michigan. Coll. Gene Hesterberg and Dow V. Baxter. Herb. Dow V. Baxter, Ann Arbor.

Fructification perennial, appearing at first in several small, bright, glistening brown patches about 3 mm. in diameter, becoming confluent and finally effused for as much as 1 meter, but usually much less, up to 12 mm. thick, mostly about 5 mm. thick, checking upon drying; margin undulate, slightly elevated, finely tomentose, 0.3 mm. wide, at first bright "raw sienna" becoming "wood-brown" or "Natal brown" in old specimens; subiculum up to 1 mm. thick, "yellow ocher" to "buckthorn-brown"; tubes becoming rather distinctly stratified, 1–7 mm. long each season, fulvous within; mouths circular, nearly regular, 5–6 to a mm., flavous to melleous when young, "yellow ocher" becoming umbrous with age, "bister," edges thick, entire; spores globose, thin-walled, smooth, pale ferruginous, but more hyaline than brown, 3–4 × 3–4 μ; hyphae ferruginous; no setae.

Allied species. — *Fomitiporella melleopora* is readily confused in the young state with *Poria pereffusa* (Murr.) Sacc. and Trott, not only because of the glistening, similar colors, but also because of the refracting nature of the mouths of the two plants. These two resupinate polypores are often misinterpreted. In addition, old plants of *F. melleopora* are so different in color and brightness (though they still glisten) from the young plants that it is possible to find immature specimens of *F. melleopora* under one name in herbaria and older plants under another. Furthermore, herbarium collections rarely represent all the stages, from young plants to stratified ones.

Although *Poria pereffusa* and *Fomitiporella melleopora* are macroscopically similar in color and although both glisten in the light when young, older specimens of *P. pereffusa* seem somewhat more woody than mature collections of *F. melleopora*, the latter suggesting a more fragile or brittle pore surface, even though it is definitely firm. The mouths of the tubes are slightly larger in stratified specimens of *F. melleopora* (mostly 5–6 to a mm.) than they are in *P. pereffusa* (mostly 6–8 to a mm.). The difference is plainly characteristic, but (as is true of many resupinate polypores) is not great enough to be of diagnostic value. There are no setae in *F. melleopora*, but setae occur in *P. pereffusa*,

though they are never abundant, often appearing in twos. The spores of both species are ellipsoid or subglobose and pale ferruginous, that is, more hyaline than brown. Murrill originally described *P. pereffusa* as having hyaline spores, in contrast to the pale ferruginous spores of *F. melleopora*. I could not find spores in the type, but Overholts reports that it is mostly sterile. On one occasion he found pale rusty spores, but on another was unable to find any spores. The small spores of *P. pereffusa* (the spores are only slightly larger in *F. melleopora*) and the setae are distinctive characters. *P. pereffusa* is most common on oak, whereas *F. melleopora* grows chiefly on species of the genera Salix and Populus.

Habitat. — *Populus balsamifera, P. tremuloides, Salix sp.* (?)

Distribution. — Louisiana, Michigan, Wisconsin.

Occurrence. — This plant is thought to be a common one, even though the records do not indicate the fact. It is believed that the inadequate records of its distribution are largely due to the plant's being so readily confused with others of the brown porias, ordinarily classified under this genus and under the genus Fomitiporia.

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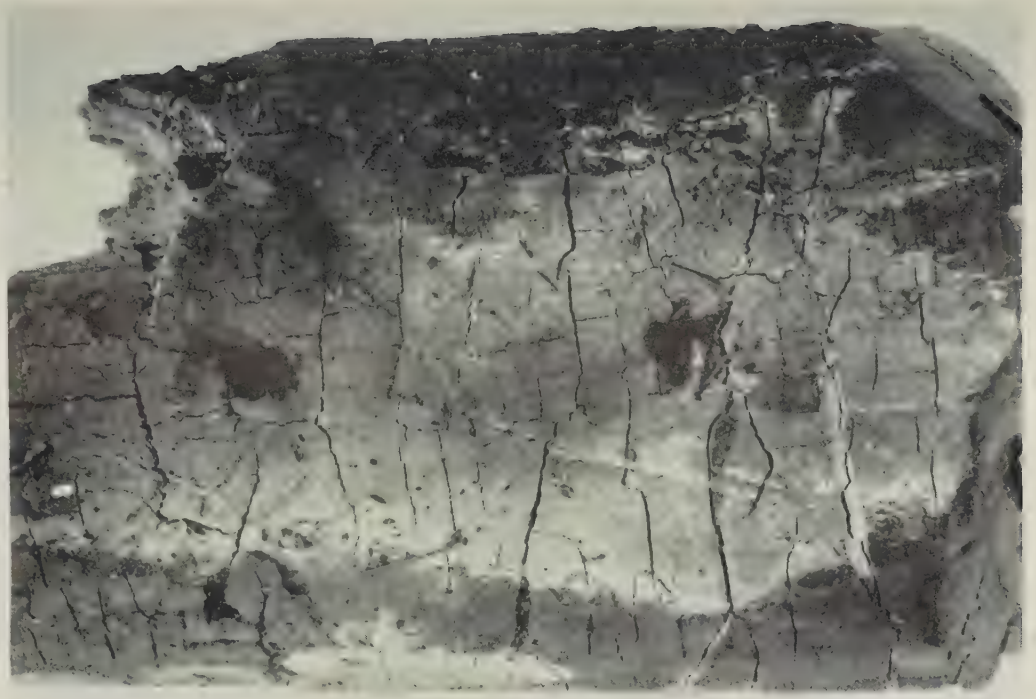
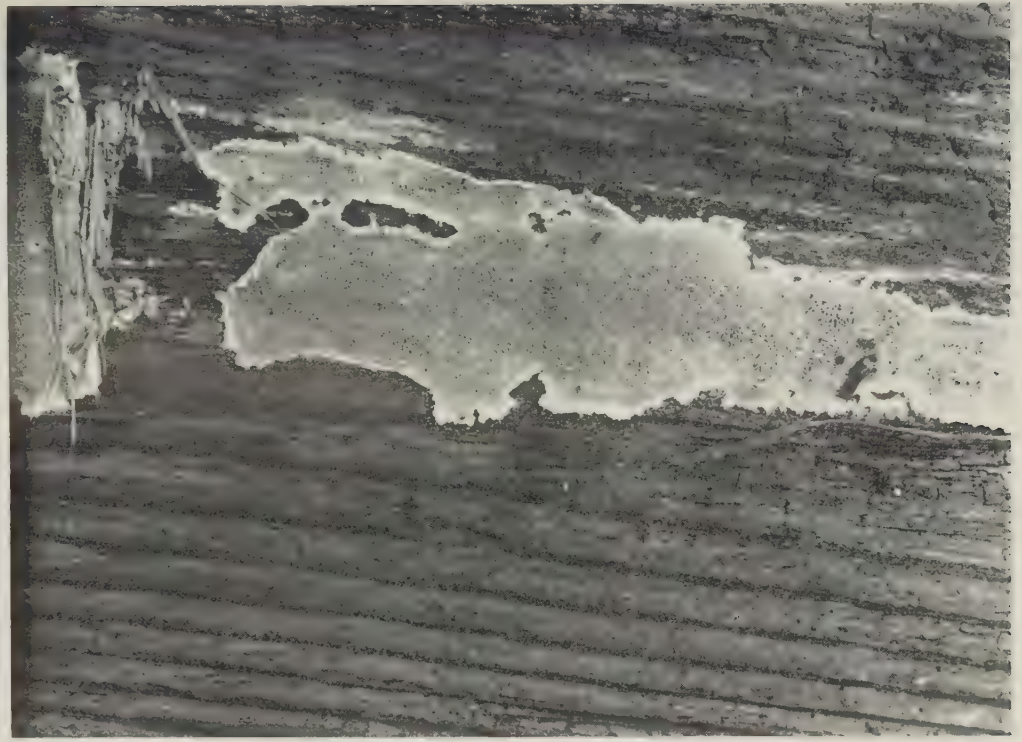
PLATES I–X

Poria herbicola sp. nov., on lawn, Ann Arbor, Michigan

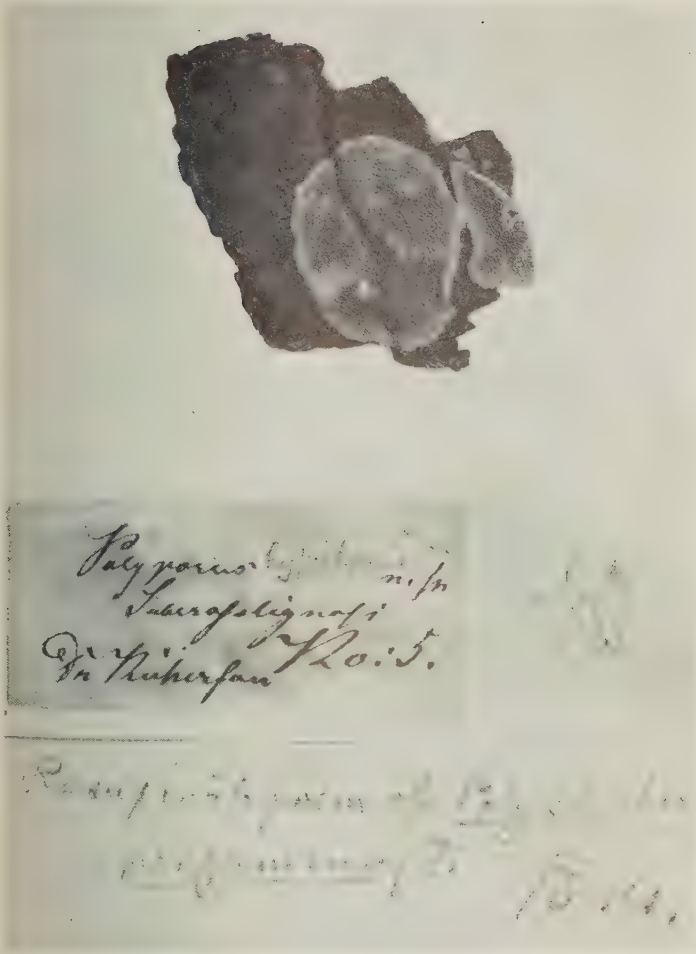


Poria Diospyri sp. nov., on *Diospyrus virginiana*, Sand Springs, Oklahoma

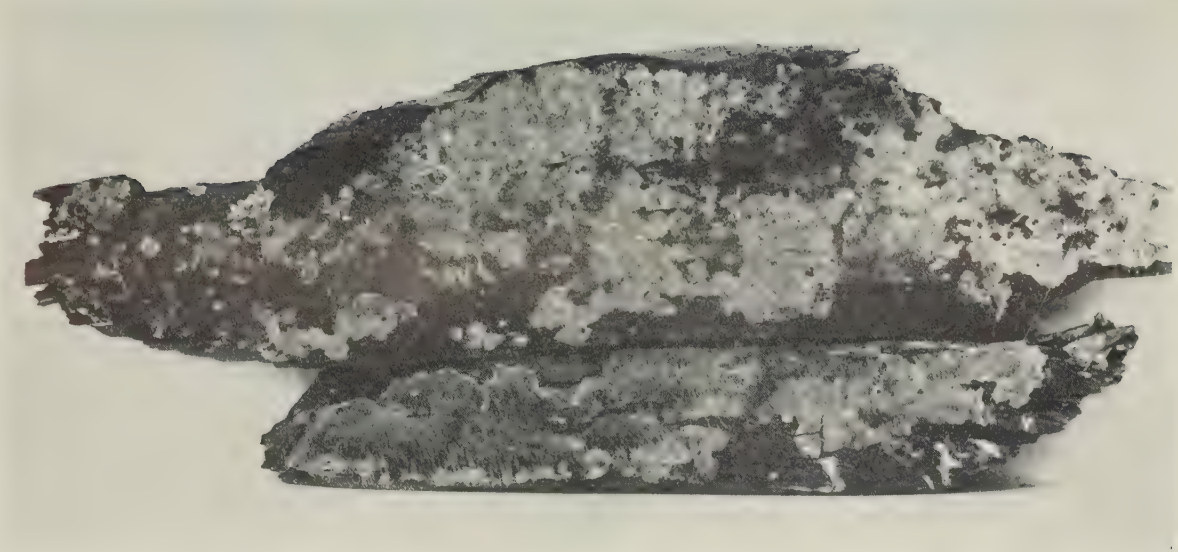
Fomes robustus Taxodii var. nov., on *Taxodium distichum*. Okefenokee Swamp, Georgia



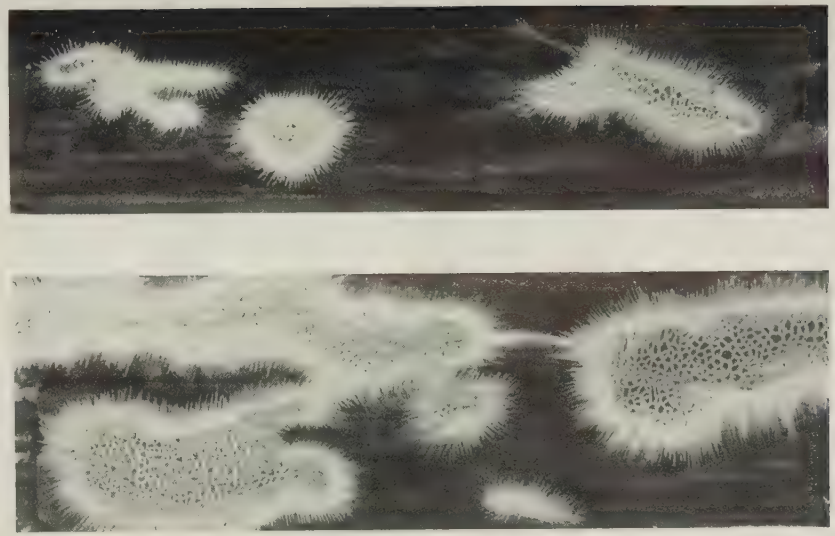
Resupinate *Polystictus abietinus* on white-spruce planking on flume at sawmill near Summerside, Province of Prince Edward Island, Canada



Polyporus hyperboreus Berk., Cooke, *Grevillea*, 15:27. 1886. Royal Gardens, Kew, England. This is evidently a resupinate specimen of a Polyporus (Coriolus) species as indicated by Cooke, probably *Polystictus* (*Polyporus*) *pargamenus*, as noted on the herbarium sheet



Polyporus abietinus thelephoroides var. nov. Lake Quinault, Washington



Poria bombycina (Fr.) Cooke, from a von Post painting directed and approved by E. Fries. Margin "pinkish buff" to "avellaneous"; mouths "cinnamon-buff." Riksmuséet, Stockholm, Sweden

Resupinate fruiting bodies of *Fomes connatus* on trunk of *Acer saccharum* in cankered area, Amasa, Michigan

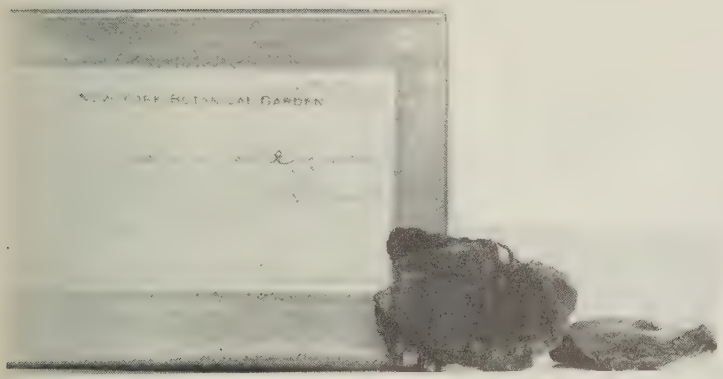


FIG. 1. *Fomitiporia pereffusa* (*Poria pereffusa* (Murr.) Sacc. & Trott.). Type. Herb. New York Botanical Garden

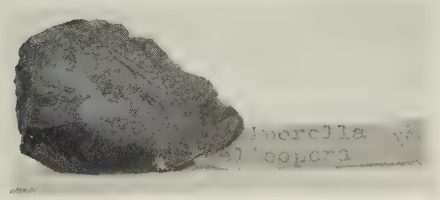


FIG. 2. *Fomitiporella melleopora*. Type. Collected near New Orleans, Louisiana, on willow log, Feb. 11, 1886, A. B. Langlois 213. Herb. New York Botanical Garden

Fomitiporella melleopora on *Populus tremuloides*. Au Sable River, Michigan National Forest, Michigan. Note the contrast between the old mature form and the patchy growth of young plants. The young plants are "raw sienna" and become "wood brown" or "Natal brown" in old-growth stages and much less glistening